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Incorporating Experiential Education into Entry-level College Biology Curriculum

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Abstract

Experiential education should be seen as a valuable supplemental component of curriculum, in addition to traditional lectures. Not only do students gain increases in factual knowledge, conceptual understanding, and critical thinking ability, but students become more engaged in the lessons, enjoy a more relevant curriculum, and add to their store of experiences for reflection. Experiential education also offers an opportunity to break down barriers and incorporate lessons from other disciplines for a more realistic and holistic learning environment. This report focuses on how to successfully incorporate experiential education into entry-level college curricula, in the form of field trips. A literature search has revealed common practices that help in successfully employing experiential education, as well as reasons why experiential education is not used as much as it should be, given the benefits it provides to students. I have described the introductory biology course field trip program from the University of Washington as an example of how to incorporate experiential education into curricula, as well as provided lesson plans for the field trips that I lead for the university. By providing these lessons plans, I hope that other educators will find useful in influencing the development of their own lesson plans, and help them integrate experiential education into their lessons.

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Learning through personal experience and reflection is the basis of experiential education. Opportunities exist through experiential education that traditional information assimilation teaching techniques lack. Experiential education moves more focus from the subject matter to the learner, with more equal contributions to the learning process from the educator and students. Students enjoy a more relevant curriculum, as well as cognitive and affective gains beyond traditional classroom lectures. Students highly rate field experiences and educators report enhanced teaching experiences (Millenbah and Millspaugh 2003). Field experiences provide the opportunity to incorporate lessons from different disciplines and invite a more holistic learning experience (Alagona, and Simon 2010). Incorporating experiential education, and utilizing the methods discussed below to increase its chances of success, should be seen as a valuable supplement to traditional classroom curriculum. Yet despite its advantages, experiential education is on the decline for a variety of reasons (which will be explored later). Fewer students are performing the lessons they learn and more are merely absorbing them audibly to be withdrawn later for a paper exam.

There are teachers that will need no convincing of the value of experiential education. For many of these teachers, it is not a lack of motivation or desire to incorporate experiential education into their lessons, or a notion that experiential education has little value in curriculum, but it is a lack of knowledge of *how* to successfully employ experiential education. This field project report focuses on incorporating experiential education into biology/ecology curriculum targeted at entry-level college students (freshmen or sophomore, typically ages 18-25). I focus on this group for several reasons; it is the group with which I have the most experience, and it is a demographic in which experiential education is most effective and more easily incorporated into curriculum. However, educators of other ages of learners should not feel that they cannot gather some recommendations and insights on experiential education from this paper.

As an example, I will focus on the introductory biology course at the University of Washington, Seattle campus, and the field trip program that accompanies the curriculum. I have designed and led field trips for this course for over two years. Not only was this project motivated by the perceived need to demonstrate how to effectively employ experiential education into college curriculum, but through my literature search, I was also eager to find ways to improve the trips I lead for the course.

First, I will seek to answer two motivating questions surrounding the target group of students:

1. What are the ways that students within this age group learn?
2. What motivates them, and how can we plan our lessons accordingly?

Second, I will examine the benefits of experiential education in curricula, and review the barriers that prevent experiential education from being used as much as it should be, given its benefits to students.

Through a literature review, I will then explore what components contribute to a successful field trip, as a form of experiential education. In doing so, I will share how the University of Washington biology field trips in general, or my field trips specifically, succeed or are limited in executing those components.

Finally, in the appendix, I have provided copies of my lessons plans for the field trips I have led for the University of Washington introductory biology course. By providing lesson plans for these field trips, my goal is that motivated teachers will glean principles and examples for how they can incorporate experiential learning into their own curriculum. Any educator may feel free to adopt and adapt whatever methods or lessons they feel may improve their own lessons, and instill more interest and engagement within their own students.

Given that students are exposed to the subject matter of the field trip for a relatively short period of time, my primary goals are to increase awareness and sensitivity, namely that students are made aware of the subject matter and the biology and problems associated with it, as well as gain experiences and basic understanding of these associated processes. Due to the limited amount of time an individual spends in the field during this course, less time is focused on attitudes, skills and participation (see Hungerford and Volk 1990). The current University of Washington biology field trips fail to help students identify and develop skills associated with environmental remediation. With what little time we have, we do what we can – primarily serving as a catalyst of interest. Of course, we cannot expect only one field trip to lead to positive environmental attitudes and behaviors indefinitely. There needs to be more frequent interventions, ideally starting earlier – previous outdoor experiences (fishing, hunting, camping, etc.), performed over a long period of time, are strongly predictive of environmental sensitivity, as well as more socially influenced (mentor, guardian, etc.) (Root-Bernstein et al. 2014).

Incorporating Experiential Education: An Example

The University of Washington Introductory Biology Course (Biology 180)

The introductory biology series is made of three sequential courses, Biology 180, 200, and 220. Each course focuses on particular topics in biology, as it prepares students for more advanced courses and to work in biologically related fields. Biology 180 (from now on referred to as BIOL 180) covers DNA, evolution and adaptations, and biodiversity; Biology 200 covers cell biology; Biology 220 covers physiology. As many biology students wish to finish the biology series within the same academic year, BIOL 180 sees the highest enrollment in fall quarter, often with over one thousand students. There are students that do enroll in winter, spring and summer quarters, but the numbers are much lower than fall quarter. BIOL 180 is also taken by many students from other majors to satisfy their breadth requirements – requiring them to take a certain number of courses outside their field, to make them more aware of other disciplines and perspectives. Ten years ago, there were only 300 students in the course, as there were other avenues that students could use to satisfy their biology course requirements (C. Spencer, pers. comm. May 14 2015).

In BIOL 180, each student is required to complete one field trip of their choice (among those offered). There are generally 10-12 students on each trip. The trips primarily focus on adaptations and biodiversity, as the lab portion does not include much about biodiversity (S. Freeman, pers. comm., May 18 2015); the lab satisfies other portions of the BIOL 180 curriculum. The field trips subjects are diverse, although most pertain to birds and forests; given that those are convenient and abundant subjects of study in western Washington. The field trips are designed by the field trip leaders; they submit proposals, and the biology administration decides which field trips are appropriate for course goals and concepts. The field trip leaders are often past students who had done well in the course, some are graduate students at the university in similar fields, while others come from outside the university.

Field Trip Goals/Outcomes

The purpose of these field trips is to demonstrate course concepts outside of the classroom and their textbook, providing more local examples of biological concepts rather than applying them to exotic and charismatic flora and fauna. A primary goal of the biology department is for students to gain new insights in biology, particularly that biology can be seen in their everyday world, and that they conceptualize more local examples of biological concepts. For example, when asked if they can name a species that exhibits sexual dimorphism, students often give examples of exotic species, like peacocks and lions, while the mallards swimming in the fountain on campus are not often mentioned. Likewise, they learn about metapopulations via forest patches (tropical and temperate) but during the microorganism field trip, they are shown that a series of sidewalk puddles can also be a good example of metapopulations.

In addition, students are able to see where biology research can be performed outside of campus, such as Friday Harbor labs, Pack Forest, etc. (C. Spencer, pers. comm. May 14 2015).

Audience

The students that attend these biology field trips are typically freshmen or sophomore students, with the majority between the ages of 18 and 25. The backgrounds of these students are immensely diverse and include students from just about every background – from ethnicity, language spoken, job or military experience, academic achievement, to socioeconomic background and other variables. In general, all these students have in common is that they are in the same course and share the same campus and environment. One of the benefits of the field trips (the campus-based ones at least) could be that students begin interpreting their everyday environment and actions through different lenses.

Stakeholder Perspectives

University/biology department/professor. The department has several priorities when choosing which field trips to offer students. They evaluate field trips on their potential to relate to course concepts, helping students do better in the course, and perceive the relevance of the course outside of the classroom, labs and exams. The department also operates within a budget, and therefore values many of the field trips that will be cheaper but still effective. Even though there are overnight field trips and field trips that go to eastern Washington, only a few of those trips are offered, because they are expensive (renting vans, paying for gas, hiring an extra driver, and longer hours for the field trip leader). Bird walks around campus and the microorganism field trips are offered frequently, as they cost much less, and serve the same number of students per trip. The department also takes the students' reviews of the field trips and the field trip leaders into consideration when deciding if the leader or field trip should be offered again. The administration particularly values field trips leaders with strong interpersonal skills that can make connections with the students and serve as a catalyst of interest and engagement for the students (C. Spencer, pers. comm. May 14 2015 and S. Freeman, pers. comm., May 18 2015). They must also be able to handle stress if something does not go according to plan (C. Spencer, pers. comm. May 14 2015 and S. Freeman, pers. comm., May 18 2015).

Students. Initially, the students' reason for joining these field trips is simply that they are required; they are there to satisfy their course requirement. At the beginning of each field trip, many field trip leaders ask students to share why, out of all the field trips available, they signed up for the field trip that they did. The most common responses include that the time of the field trip worked with their schedule (classes, jobs, other priorities), cost (some field trips require fees for certain destinations), that it was the only field trip remaining, and other practical reasons. It is uncommon for a student to say that the reason they signed up for a particular field trip is because they are personally interested in the subject matter of the field trip. When designing field trips, leaders are encouraged to take time, cost to the student, and interest into account.

Pedagogy of Entry-level College Students

Adult vs. Child Pedagogy

While it may seem obvious to many, it does bear stating: You cannot teach adults in the same ways that children and adolescents can be taught; adults have ways of learning that are different from these groups (Bass 2012). In order to effectively teach and achieve a curriculum's educational outcomes and goals, we must stop designing our curriculum around the subject and begin constructing it around the leaner.

Compared to primary and secondary schooling, participation in adult education is largely voluntary (Merriam et al. 2007). It is encouraging to see that adult education is on the rise, with more adults entering formal and informal learning environments than ever before (Merriam et al. 2007) – this appears to be a product of a generation of lifelong learners. The average age of the college student is the oldest it's ever been (Bass 2012; Merriam et al. 2007).

The reasons adults participate in continued education are about as varied as the participants that take part in it, but the general pattern is that learning is embedded in their on-going contexts. In "The Inquiring Mind" (1961) (cited in Merriam et al. 2007), Houle found three different types of learning orientation in adults. Goal-oriented learners engage in learning to acquire training in a new skill or set of skills - this may be related to job training or a change in vocation. Activity-oriented learners are focused on the activity or subject itself, and often the social interaction with those also interested in that activity. Learning-oriented learners pursue knowledge for its own sake. Of course, none of these are mutually exclusive.

Knowles (1980) distinguished adult learning from pre-adult learning as andragogy<confusing order; put term by what it applies to>, in contrast to the term pedagogy. He established a list of assumptions about the adult learner as they differ from child and adolescent learners. This isonly a framework – it is not absolute and does not account for the wide variation between individual adult learners.

1. The self-concept of the learner moves from a dependent personality to that of a self-directing individual, as a person matures.
2. As one grows older, the accumulation of experiences serves as a resource for learning and reflection.
3. The readiness of an adult to learn is related to the developmental tasks of their social role.
4. Changes in time perspective – from future application of knowledge to immediacy of application – adults become more problem-oriented than subject-oriented.
5. Adults become more internally motivated rather than externally motivated.
6. Adults want to know why they are learning something (the problem, how it relates to their daily lives, how they can utilize it, etc.).

The context of education is a major difference between child and adult learners (Merriam et al. 2007). A child is largely dependent (but not wholly) on others to initiate, guide and evaluate their learning. Adults, on the other hand, have largely assumed responsibility for themselves. The andragogy/pedagogy dichotomy may be seen instead as a gradient from directed by an instructor on one end, to directed by the student at the other. When seen this way, this can be used in both children and adults, dependent on the situation (Merriam et al. 2007).

Transition Period

The majority of students in the University of Washington's introductory biology course (see Example) are between the ages of 18 and 25. While entry-level college students may legally be considered adults, they do not fall into one distinct category of learners – adults or children. Many may be living on their own, away from their parents, for the first time in their lives (or they may continue to live with their parents), while others may be enrolling in higher education due to a career change. For whatever age the learner is, this is a transition. For those young adults, this is a transition not only into a different realm of learning, but from adolescence into adulthood. Primary and secondary schools in Western societies primarily approach education with a deficit model (Itin 1999; Russell 1999). They transition from this traditional, mandatory educational model to a voluntary one with much more personal responsibility. In doing so, the students move from an approach of absolute knowing to one of contextual knowing, from an area of instruction to an area of facilitation (Merriam et al. 2007). Progress with this transition does not occur at the same rate for all students.

Even though entry-level college students may now process information more similarly to adults than as children, they have fewer experiences and prior knowledge to draw from than older adults (Merriam et al. 2007). Chickering (1993), in his work with young adults transitioning into college education, described seven changes students of this age work at developing. These changes are absolutely not linear in the order they are listed, and individual students may experience each change at a unique rate.

- Developing Competencies: As in secondary education, students are continuing to develop competencies in cognitive, physical and interpersonal skills.
- Managing Emotions: Similarly to developing competencies, students are learning to identify and understand their emotions, and act appropriately with them.
- Autonomy toward Interdependence: In the transition into adulthood, students may see themselves as finally independent, but they are also seeing their connections through others in society. According to Chickering, this also includes an increase in problem-solving skills, initiative, and self-direction.

- Mature Interpersonal Relationships: In exchanges with people from diverse backgrounds, students are exposed to new perspectives, and learn to understand them. They are also beginning to develop or identify their meaningful, positive relationships.
- Establishing identity: Students are becoming comfortable and confident with who they are; there is much more resistance to peer pressure than in primary and secondary schooling. This also means that they are learning to handle criticism from others.
- Developing Purpose – The students begin to develop goals and commitments for future endeavors. These are often vocation related. This also includes following through on these goals and commitments.
- Developing Integrity – The student develops a core set of values that are acted on, but also identifies and respects values held by others.

Prior Knowledge

"Lindeman (1961, pg. 6) states that 'the resource of highest value in adult education is the learner's experience.' Experience then becomes 'the adult learner's living textbook…already there waiting to be appropriated'" (Merriam et al. 2007, pg. 7).

While the typical entry-level college student may not possess the wealth of experiences of an older adult, they nevertheless possess previous knowledge gathered from years of schooling and non-academic pursuits. These experiences have already formed perspectives, opinions and convictions within them – they are no longer inexperienced minds, having been exposed to math, science, the arts, humanities, and many other core classes in high school, as well as a myriad of social interactions. This knowledge serves as the starting point with which new knowledge is constructed. Prior knowledge and experiences of students are not limited to only factual and conceptual knowledge, but also emotions associated with those experiences. It is therefore important to address these – work through the negative emotions and play off positive ones. Negative emotions related to a subject can block engagement and, therefore, learning (Merriam et al. 2007). In particular, many students come into higher education with a notion that science is difficult to understand, and they may believe that it is beyond their ability or comprehension to understand and perform it – a result of previous experiential learning (Bass 2012). It is a common assumption that science is boring and indecipherable (Bass 2012). Ideally, students would be exposed to science in more positive and encouraging ways in elementary and secondary settings. They would already have a set of assumptions based on valid information instead of negative emotional triggers.

Therefore, it is important to know the backgrounds and experiences of the participants, including culturally and socially. This becomes a real challenge with adult education, as adults have comparatively richer life experiences than child learners (Merriam et al. 2007), and the diversity of experiences and backgrounds makes it difficult to provide general lessons. "If learning in adulthood is embedded in its context, a single set of principles is not likely to hold true for a wide-ranging diversity of learners and learning situations" (Merriam et al. 2007, pg. 422). This is where handing over more control to the students is vital – invite students to share what they know.

Internally Motivated, Goal-oriented, Self-directed Learners

One of the goals of public schools, colleges and universities is to enable students to become productive, self-directed, lifelong learners (Bass 2012; Kolb and Kolb 2005). One assumption is that because one attends college, it is because they want to be there – as it is voluntary and requires great amounts of financial resources and time. However, there may be a perception among prospective college students that college is required, at least to attain a job that will provide for a comfortable living (Aslanian 2001 – cited in Merriam et al. 2007).

Rather than being externally motivated, as many students in traditional primary and secondary education are (i.e. motivated for grades, avoiding discipline for lack of attendance, etc.), adults are more internally motivated and goal oriented. As such, much of the control in the learning process needs to be shifted to the learner in adult education settings (Merriam et al. 2007). However, in their transition from high school to college, many students may still feel more externally motivated rather than internally. Adults are not inclined to engage in learning unless it is perceived as meaningful, whereas children are conditioned by school. Often, motivation in adults is stimulated by a life event or changes in the socio-cultural world; being more problem-oriented, the participant's expectation when engaging in learning is that they will be able to put what they've learned to good use in their everyday lives (Merriam et al. 2007).

Because entry level college students are becoming more goal-oriented, concentrating only on getting students outside does not constitute experiential education. The educational experiences must connect to the pedagogy/andragogy of the students in order to achieve desired curriculum outcomes (Myers and Jones 2004; Russell 1999). Connecting educational experiences to the learner's world generates intrinsic motivation and increases learning effectiveness (Kolb and Kolb 2005). Traditional schooling is largely decontextualized; there is little transfer between school and the real world of the students (Merriam et al. 2007). Adults desire situation-specific competencies instead of general knowledge from their learning, unless they have engaged as a learning-oriented learner only.

Many students enter college from a deficit model that traditional schooling typically employs, where the learner is seen as lacking the knowledge or skill that the educator is offering (Itin 1999; Russell 1999). Given such a change, they may not be prepared for the very different learning environments that college provides; they may still feel as though they need external guidance, and that they are not equipped with the skills for self-directed learning (Kolb and Kolb 2005). G. Grow (1991) offered a stage approach to develop self-directing learning within students. As with Chickering's changes in transitioning students, not all students will proceed through these stages at the same rate. Stage 1 may typify the learner as they enter the college environment from high school, while the goal is to move them to become a motivated, self-direct learner in Stage 4. These stages can be used to incorporate self-directed learning methods into formal teaching environments/programs. Enabling students to become self-directed learners enables them to discover which ways they learn best, as well as to understand the skills needed to learn in areas where they are least comfortable (Kolb and Kolb 2005). Experiential education and field trips can work great in this regard: the varied learning environment gives opportunities to learn in very different ways than in a classroom, giving the student more control over their own observations, as well as adding a sense of relevancy and building their collection of experiences.

Grow's (1991) Staged Self-direction Model:

- Stage 1: Dependent learner (as they enter higher education)
  Learners of low self-direction who need an authority figure (a teacher) to tell them what to do. Introductory material, lecture, immediate correction.
  Teacher role: Authority/expert.

- Stage 2: Interested learner
  Learners of moderate self-direction who are motivated and confident but largely uninformed of the subject matter to be learned. Intermediate level – lecture-discussion. Applying the basics in a stimulating way.
  Teacher role: Motivator.

- Stage 3: Involved learner
  Learners of intermediate self-direction - who have both the skills and the basic knowledge and view themselves as being both ready and able to explore a specific subject area with the assistance of a good guide. Application of material, facilitated discussion. Group work, critical thinking, learning strategies.
  Teacher role: Facilitator.

- Stage 4: Self-directed learner
  Learners of high self-direction who are both willing and able to plan, execute, and evaluate their own learning with or without the help of an expert. Independent projects, student-directed discussions, discovery learning.
  Teacher role: Expert, consultant and monitor (delegator).

Grow's model moves the student from the typical dependent learner that emerges from the realm of traditional high school, and provides the learner with progressively more educational freedoms and responsibilities. This prepares them for the role of the life-long learner, able to identify and pursue solutions to problems they will encounter throughout life.

Critical Reflection

Critical reflection is an important stage to incorporate into any form of adult learning (Bass 2012). Through critical reflection, adults are able to use what they have just experienced to challenge previous held perspectives, viewpoints, or reexamine past experiences. Critical reflection is required for curricula that are seeking some kind of transformation (transformational learning) within their students; if the learner does not reflect critically on their experiences, they cannot learn as much from them (Bass 2012, Merriam et al. 2007).

Critical reflection may take many forms in adult education. In small groups, where students generally feel more comfortable and open, it can be employed through facilitator-led discussion. The use of reflective journaling is an effective strategy to give more time for critical reflection to accomplish its purpose. The facilitator can further their role by posing thought-provoking questions for participants to consider when journaling.

Conclusion

There is no single, unifying theory of adult learning; there is far too much diversity within the participants and research perspectives for an overarching prescription. However, the above has summarized several generalities or similarities between adult learners that are useful for educators to keep in mind when designing program curricula.

The challenge, however, is how to best design curriculum for students transitioning from adolescence (an age where learning is subject largely to external motivation) to adulthood (where learners are more self-directed and problem centered), who are developing their sense of identity (Chickering 1993) and identifying their skills. Even though learners at this age may possess less prior knowledge and past experiences to reflect on, the diversity amongst learners is still incredible and should not be discounted (Merriam et al. 2007).

For learning to best occur, the experience must connect to the past experiences of participants, as well as provide avenues for further learning to occur, in addition to grounding that experience in the curriculum; “In other words, experiences that provide learning are never just isolated events in time” (Merriam et al. 2007 pg. 162). Such experiences and learning opportunities, such as collaborative learning activities, self-directed research projects, and self-reflection and peer reflection, abound in science.

To meet the goals of environmental education, it is important to help students to connect the content to their everyday experience(s), so that they can better independently gain and generalize environmental knowledge to their choices. While this may not be the main purpose of the field trips, they are meant to help students to see biology in their everyday lives, and understand how it is all connected, regarding the subject matter of their field trip at the very least. Once they begin to see how biological systems interact in their own lives, through lessons in the field trips and classroom lectures, it is hoped that they can relate their own actions and influences to environmental issues. Knowledge is a prerequisite to action, although it would take considerably more exposure to develop the intent to act (Hungerford and Volk 1990). I am satisfied in increasing awareness of biological systems in a majority of the students, given the short time to implement the field trips, and thrilled when I hear of the students that change majors because of the trips or overall course experience.

The Value of Experiential Education

Before the values and methods of experiential education are discussed, we must first define what we mean by experiential education, as there have been many synonyms.

Experiential Education:

> "Experiential education is a process through which the learner constructs knowledge, skills and value from direct experience" (Association for Experiential Education 1994).

Experiential education encompasses many different forms of education and learning through experiences, including experiential learning, but also service learning, outdoor education, cooperative learning, adventure-based, action learning, transformational learning, etc. (Itin 1999). Traditional educational practices take a deficit model approach to education, seeing the student as devoid of desirable information that the teacher has (Itin 1999; Russell 1999). While grade school has a relatively large amount of experiential education built into the curriculum, this is replaced largely by lectures (information assimilation) in junior and high school (Millenbah and Millspaugh 2003).

Many historical educational philosophers saw education instead as a transaction between teacher and student – acknowledging that students also brought experience and knowledge to the educational process (Itin 1999). This meant that teachers actively engaged with the students, rather than simply lecturing, and provided understanding of the subject matter through experience. First-hand experience provides for unique opportunities not found in the classroom (Myers and Jones 2004), and provides the greatest motivation for future learning (Sibthorp et al. 2011). Reflection of the learning experience is always a key component of experiential education (Itin 1999; Simpson 1999). These components will be explored further below.

Experiential Learning:

Experiential learning is a method of experiential education, even though they may seem to be synonyms. Experiential learning consists of 4 components as described by Itin 1999:

1) Action that creates an experience.
2) Reflection on the action and experience.
3) Abstractions drawn from the reflection.
4) Application of the abstraction to a new experience or action.

Action is the most important portion of the learning cycle, as it takes the students' knowledge and reflection into the real world (Kolb and Kolb 2005). Upitis et al. (2008) described the use of multiple senses during an experience to make the most of the action. Reflection is key to experiential learning, just as it is to many forms of adult learning (Bass 2012). The goal is that students will be able link insights from current experiences with previous ones, as well as see future implications of what they have experienced (Merriam et al. 2007).

While field trips, as a method of experiential education, may be the focus of this paper as an example of incorporating experiential education, field trips are not the only way to incorporate experiential education into natural history and science curriculum. For urban and inner city schools, transportation can be costly and prevent such experiences. There are multiple opportunities for experiential learning to come into the classroom, if that's what it takes. Classroom pets, raising insects and observing metamorphosis, experiments and studies with plants - these are just a few examples. Students can also be given projects at home, whether that be selecting some urban/suburban wildlife to study, a vacant lot to search, and have them write their observations and reflections in a journal.

Service learning is another form of experiential learning that is often utilized, especially useful if critical reflection through journaling is performed. Service learning can also provide the student with more culturally relevant ways to interpret and view the curriculum (Colvin and Tobler 2013). Culturally relevant curriculum can be important to students (Colvin and Tobler 2013, Dillon et al. 2006). Recognizing that students from different cultures come with different ways of learning is critical for effective teaching and providing for meaningful experiences. Curriculum that is not seen as relevant (or not made to be relevant through engagement) to the student's world can cause the student to become disengaged in learning. Being culturally relevant is a real challenge in large university or community college with students from many different backgrounds.

What Is Experience?

A word that may seem to need no explanation is actually fraught with ambiguity. The meaning of the word experience, and its implications in experiential education, is worthy of an entire thesis, and will only be mentioned here.

A common model of reasoning for the use of experiential education in environmental education is that experiences will lead participants to care more about the subject (Russell 1999), and instill a sense of conservation need and action. Similarly, one goal of environmental education is behavioral changes to improve sustainability; the assumption is that experiencing the environment will lead to action to conserve it.

Nature experience → Caring → Commitment → Action

An experience belongs to the person taking part in the experience. One assumption is that an experience is transparent (Fox 2008), and that if everyone witnesses the same thing, that that experience will affect everyone the same way (Russell 1999). It should be noted that even though a group of students may be in the same place, at the same time, studying the same subject, everyone will experience the activity at least slightly, and sometimes profoundly, differently. Learning is strongly influenced by previous experiences that shape current perspectives and worldviews (Dillon et al. 2006; Fox 2008, Haluza-Delay 2001). New experiences can also force new interpretations of past experiences (Fox 2008, Russell 1999).

Experience is at once an interpretation and is in need of interpretation (Fox 2008; Russell 1999). Prior knowledge and experience can have a great effect on the outcomes of a learning experience (Ewert and Sibthorp 2009). Therefore, educators have the responsibility to help students to make meaning from an experience (Fox 2008), whether through leading discussions, posing questions for future reflection, etc.

Why Is Experiential Education Important To Incorporate Into Lesson Plans And Curriculum?

For many fields of study, experiential education is an assumed form of education. An aspiring artist would be ill-advised to consign themselves to only the study of art, rather than its practice. Would we expect beautiful music if a musician had only observed others playing their instruments? And how confident would we be in our doctor had they never performed a surgery, even though they may have aced all of the classes and exams? “Many courses will spend 15 weeks requiring students to take in volumes of information and only a couple of hours expressing and testing their learning, often on a multiple-choice exam. This is in contrast to arts education built on the demonstration-practice-critique process where active expression and testing are continuously involved in the learning process” (Millenbah and Millspaugh 2003 pg. 208).

So why, then, is experiential education so difficult to find in other fields of study? Here, I will focus on the biological sciences, as this is the field I have the most experience in. However, as well as the previous examples mentioned above, the biological sciences is not the only field that benefit from experiential education (Alagona and Simon 2010, Greene et al. 2014, 2015; Knecht-Sabres 2013).

Benefits of experiential education. Much research has illuminated the value of experiential education, in curriculum, namely field trips. According to Hoad et al. (2013), outdoor learning experiences afford much that classroom based learning does not. Cognitive, affective and behavioral boundaries are pushed, roles of the teacher and student change, and students often gain new perspectives from their experiences and interactions with their classmates. Being outside of their comfort zone can trigger emotional engagement. In addition, the movement from more artificial settings to more natural settings provide for a greater sense of relevance, even if the experience is not necessarily related to the student's personal life (Knecht-Sabres 2013). In addition, students can draw insights from other disciplines and observe how they interact with the subject matter (Alagona and Simon 2010). Such integration of interdisciplinary concepts invites a more holistic learning experience for the student, a central aim of environmental education.

DeWitt and Storksdieck (2008) argue that in addition to affective gains (such as increased motivation or interest, attitudes toward the topic, or sparking curiosity), the true value in field trips is the creation of first-hand experience and the opportunity to perform hands-on exploration. While many teachers, because of many of the barriers to field trips discussed below, think that opting for a video may substitute for a field experience, Greene et al. (2015) found that a video resulted in half the gains than obtained from a live, personal experience. Digital learning methods do not offer the multidimensional experience and gains that a field experience has in which all senses are involved (Behrendt and Franklin 2014). Field trips yield higher rates of factual knowledge, conceptual understanding and critical thinking ability than classroom lessons (Behrendt and Franklin 2014; Greene et al 2014; Knecht-Sabres 2013; Millenbah and Millspaugh 2003; Myers and Jones 2004). Field trips, as a form of experiential education, in addition to their value in developing cognitive skills, can also provide for positive affective and social experiences (Courtney et al. 2014; DeWitt and Storksdieck 2008; Dohn 2011; Greene et al. 2014, 2015), as well as increased interest in and relevancy of the topic (Dohn 2011). Experiential education, and what Freeman et al. (2014) calls active learning, generally increases examination scores, leading to more engaged students that are less likely to drop out (Active learning is not the same as experiential learning, but active learning can be easily incorporated into experiential learning – see Millenbah and Millspaugh 2003). Utilizing experiential education in curriculum also provides a great affordance in academic settings: it reproduces more realistic scenarios in which the students will find themselves in their professional or personal lives. By experiencing error and failure in an academic setting (where failure and error is more permissible than a professional setting, and may be seen as a learning opportunity), they will be more prepared to consider other options and actions than their counterparts who simply received a lecture on the same methods (Millenbah and Millspaugh 2003).

Research has shown not only the short term cognitive, affective, and social benefits of experiential education, but also the long term impacts it can have on people. Field experiences at a young age, including many details and the content matter, can be recalled well into adulthood, with nature centers or natural areas being recalled most often (Falk and Dierking 1997). A survey of university students indicated the school field trips to science centers influenced their decision to continue studies in science (Salmi 2003 – cited in DeWitt and Storksdieck 2008).

Why Is Experiential Education So Underutilized In The Biological Sciences?

Field trips, as a form of experiential education, are on the decline in many primary and secondary schools (Greene et al. 2014; Mehta 2008; Popescu 2008). By the time students have reached college, many have not had the out of the classroom experiences that many of us remember. At the beginning of the University of Washington's introductory biology course (Biology 180) field trips, I usually ask students if they have done the upcoming activity before (actively looking for birds, exploring a Western Washington forest, etc.). It is not uncommon for the majority of students, if not all of them, to admit that they have never done such an activity. There have been many emerging barriers, in addition to traditional barriers, that hinder students' ability to enjoy new experiences outside of the classroom. Because of these increasing barriers and having had no experiential education incorporated into their curriculum, students often arrive at college with the perception that learning is something that takes place within the four walls of the classroom. The most common barriers to quality, outside of the classroom experiences include, but are not limited to:

Rising costs and decreasing budgets. As operating costs rise, and schools are asked to do more with less, field trips are often pushed by the wayside, often deemed too expensive (Behrendt and Franklin 2014; DeWitt and Storksdieck 2008; Dillon et al. 2006; Greene et al. 2014; Mehta 2008; Myers and Jones 2004; Popescu 2008). It should be noted that the sciences aren't the only academic subjects suffering from budget shortfalls. Many other academic subjects that utilize experiential education have not been able to operate as they once did, such as music and the arts (Mehta 2008).

More stringent curriculum. Due to federal mandates that award funding for academic performance, there has been increasing pressure to teach to the test in order to increase test scores and secure funding (Mehta 2008; Popescu 2008). Field trips and other experiences have increasingly<data / source for this trend?> been seen as superfluous, with their value being questioned if they were not directly related to increasing test scores (Behrendt and Franklin 2014; Dillon et al. 2006; Greene et al. 2014; Myers and Jones 2004). According to Courtney et al. (2014), "such a trend (more time in class prepping for tests than on field trips) makes it imperative that teachers, schools, and school districts know which characteristics and qualities of field trip sites support students' learning in the classroom" (p. 156). Now, if any field trip is performed, it is more likely than ever to be seen as a "reward" field trip, taking students to places that they already enjoy, and not be seen as a learning opportunity (Greene et al. 2014, 2015). This may further cause new teachers to see field trips as lack teaching potential.

The decrease in field trips can be seen as a form of social injustice. Disadvantaged students (rural, inner city, minority, etc.), who show more significant gains than other students (DeWitt and Storksdieck 2008; Greene et al. 2014), are less likely to have these enriching experiences if the schools do not provide them; more advantaged families are more able to afford these experiences and substitute them outside of school hours, whereas students from disadvantaged families may not (Greene et al. 2014).

Fear and concern about health and safety (liability). Students may be exposed to serious risks in experiential education environments (Schumann et al. 2010). Although these risks may not be objectively greater than some everyday risks, their novelty and the media attention they may receive increases potential public alarm should a mishap occur, increasing administrators' perceived risk/benefit ratio (Brown 1999). In a climate of blame and lawsuits, the perception of risk for a field trip has become far greater, and many administrative staff choose to err on the financially safe side, and forego any field trips. <ties it to below: admin's unfamiliar with managing field trip risks, and thus even if teachers had confidence, admins might over-rule. A cultural thing too -- compare nature kindergartens in germany, sweden, where risk is accepted & individual child's need to become competent with them is a goal.>

Teachers' lack of confidence in teaching outdoors. Many teachers are strained with the available time to do all that they want – from providing more individualized attention to a student's needs, to giving the students experiences beyond the ordinary and exposing them to new ideas. While the desire to teach students outside of the classroom may be present, there may be a perceived lack of knowledge or ability to do so (Dillon et al. 2006). They do not wish to lose any trust in their students, nor do they wish to waste the class' time. Unfortunately, very few pre-service teachers receive training in field trip/experiential education planning (Behrendt and Franklin 2014). Once educators receive training on field trip planning and pedagogy, they are more likely to plan more field trips in the future (Ferry 1993; Tal and Morag 2009). In addition, many new teachers have had few, if any, outdoor experiences during their time in school, and therefore have little to model their own practice on.

Not enough chaperons. This is primarily a concern for younger students, given the number of distractions that may prove difficult in keeping attention and to further aid in safety (Mehta 2008).

The Advantages Of The College Environment

In contrast to primary and secondary educational settings, employing experiential education in entry-level college courses provides opportunities that are not available in primary and secondary schools.

First of all, the vast majority of entry-level college students are now considered adults; they are able to provide their own consent to waive liability for out of the classroom experiences, as well as exercise better caution and judgement. Even so, I am in no way advocating that safety should be any less of a consideration than in primary and secondary schools, where parents must give their consent. As legal adults, college students do not need chaperons, as they did in primary grades, although students should still be given a set of guidelines for conduct in the field, specific on the environment to be explored and activities to be performed, for the sake of safety and organization.

Colleges do not have to secure funding through standardized tests. Funding can be secured through the administration of course fees to the students. Given the rising costs of tuition and college related expenses, it is advised that experiences planned take into account the costs for the students, and attempt to make them reasonable.

What Will It Take To Effectively Employ Experiential Education?

My literature search has revealed several components that contribute to a successful field trip, a field trip where goals and outcomes are met, learning and cognitive gains are achieved, and participant engagement is fulfilled. While strong models for a field trip do not appear readily in the literature, Myers and Jones (2004) provided a helpful outline of a well-planned field trip. This list is certainly not exhaustive, but serves as a good starting point for teachers to consider when planning experiences for their students. Many of the components will be explored further below.

Components of a well-planned field trip (Myers and Jones 2004):

Myers and Jones divided the field trip into three sections: pre-trip, the trip itself, and post-trip.

- Pre-trip
    - Administration – all logistics
    - Instruction – preparing students for the experience.
        - Reduce anxiety – comfort and safety are assured
        - Vicarious exposure
        - Content topics and concepts

Before the trip, the facilitator would prepare everything needed for the trip to be a success. Logistical aspects would be taken care of during this time, such as transportation, Acknowledgment of Risk and Hold Harmless forms, etc. This would also include preparing the students for what they would be doing during the trip and what they would learn, as well as preparing them for the potential hazards, so that emergencies would be less likely to occur.

- The trip
    - Role(s) of the participant

  - Role(s) of the organizer

There is then the trip itself, including all the activities and experiences, planned and unplanned. It is helpful that students and the facilitator know their roles, so that the trip goes smoothly.

- Post-trip
  - Debriefing
    - Reflect, share and discuss participant experiences
  - Culminating activity

The post-trip is where everything experienced during the trip is shared and discussed, as well as experiences and lessons related back to the curriculum. An activity, assignment, or project can also continue the lessons learned during the experience, and provide for further reflection on the subject and experience.

Small group. Research shows that engagement is highest with others (DeWitt and Storksdieck 2008; Dohn 2011; Freeman et al. 2014; Kolb and Kolb 2005; Sibthorp et al. 2011; Wolfe and Kay 2011). Students have the opportunity to learn from each other by sharing their discoveries and insights as well as reflect on their own experiences. Too many students can cause obvious logistical problems for field trip facilitators and, as in many classrooms with large numbers of students, many students do not feel that their concerns and learning are being adequately addressed. Students in large classrooms may extricate themselves from the lessons.

Small groups allow students to ask more questions, do more hands-on work, and work closer with advanced students and faculty in the discipline (Price and Hein 1991 – cited in DeWitt and Storksdieck 2008). Reducing the number of students may increase trust and openness that a room full of students may inhibit, resulting in more open and honest discussion (Alagona and Simon 2010). This is important in developing empathetic learning communities in college –level education (Barrett 1997), where students are exposed to new perspectives and the experience of others. This becomes particularly apparent in large public universities where there is tremendous diversity in the students.

In BIOL 180, a class of over one thousand students during fall quarter, the risk for students to disinvest themselves from the lectures and programs is great. The labs help to serve as a smaller group within this larger lecture course, but this is still typically a class of over 20 students. The field trips further advance the small group tool for optimal engagement, with less than 12 students on a trip.

Pre and post-trip lessons. As components of a well-planned, successful field trip (DeWitt and Storksdieck 2008; Myers and Jones 2004), pre-trip and post-trip activities can serve to reinforce lessons, experiences and insights from field trips (Behrendt and Franklin 2014; Courtney et al. 2014).

Visits to new areas can trigger some undesirable anxieties, especially in students where the entire outdoor experience may be new to them – whether it's the activity or some previously held phobia about the environment to be explored (or the "wilderness" in general). This is where pre-trip visits can serve to lessen that anxiety as well as increase the anticipation of the upcoming trip (Ballantyne and Packer 2002; Dillon et al. 2006). It also serves to inform the students of the activities or itinerary, the goals of the trip, and other logistical aspects so that the experience will more likely go smoothly. Information such as distance traveled, gear needed, terrain or wildlife to be cautious about, or sights to be seen can greatly increase anticipation of the trip and ease anxiety. The less that is unknown will settle nervous minds and prepare them to learn and engage in an outdoor learning experience (Ewert and Sibthorp 2009). In addition, students learn the most when they already have some preliminary understanding of the topic (DeWitt and Storksdieck 2008).

One of the goals of experiential education is that students can produce general concepts from one experience and apply it to a new experience. This can be difficult for some students, and can be aided through post activity discussions (Millenbah and Millspaugh 2003). Post-trip activities need to draw connections between the outdoor experiences of the field trip and the curriculum in the classroom for effective learning to take place, and for the field trip, and school in general, to seem relevant to the student's world (Behrendt and Franklin 2014; Dillon et al. 2006). Post trip activities can also be used to assess the effectiveness of the experience and help to identify weaknesses that need addressing.

Unfortunately, due to the time constraints of the ten week quarter system, as well as the number of students, executing pre and post-trip lessons is impractical. Therefore, a number of connections are likely missed because of this limitation. Connections to the curriculum are achieved as best as they can through end of trip discussions and questions posed by me to the students in the field. Pre and post-trip lessons may be more easily achieved in the smaller class sizes of the community college.

Novel area. Novel areas and activities that create new stimuli generate attention and curiosity and lead to engagement (DeWitt and Storksdieck 2008; Dohn 2011; Hoad et al. 2013; Wolfe and Kay 2011). However, a novel area can also be distracting from the goals and desired outcomes from an experience (imagine a student taking part in a field trip in winter and experiencing snow for their first time, while trying to concentrate on the lessons at the same time). While novel areas can be engaging, this can also have a negative effective on learning if students are not prepared, as they would through a pre-trip lesson (Behrendt and Franklin 2014; Dillon et al. 2006). Novelty depends on the situation and the students' previous experiences (Dohn 2011) – this is therefore demanding of the facilitator to constantly supply a plethora of novel experiences, as well as connect the current to and build on the students' past experiences.

As the field trips arrive at their destination, I often ask if the students have ever been to the area before, or if the activity is novel to them as well. It is very common that the area and activity are both new to the students, and distraction from the subject matter has occurred. This is where I have learned to not over structure my lessons, and allow some time for inquiry (see below).

The field experience/methods in the field. Even if the area is not new to the students, it may still be unusual for a class to step outside the four walls of the classroom. Students report increased focus during outdoor experiences (Alagona and Simon 2010). This may be attributed to a perceived sense of simplicity (as students report) – there is little to distract them from the course material, neither can they do anything about other priorities and concerns at that time. This is understandable, given the fast-paced lives of college students –employment, physical time in class, assignments, as well as other extracurricular activities; there is little time to slow down.

The field trip is where students practice the fundamental activities of the discipline. As in labs (but in an entirely different realm), they are able to test generalizations, question and understand results that don't fit with their preconceptions. In other words, they discover how science works by doing it, rather than just taking a lecturer's word for it. The field trips of the University of Washington's introductory biology course aim to connect the biology that students are learning in the classroom to their everyday world. Subjects, such as birds and plants, are often chosen as they are commonly observed by students who can engage the conceptual foundations of science themselves.

During the field experience, creation of hands-on activities is popular with students (Dohn 2011), and allows more use of more of their senses that may affect memories and perceptions (Upitis et al. 2008). If possible, planning for some animal/wildlife interaction is very popular, especially physical touching (Ballantyne and Packer 2002; Dohn 2011) – however, this raises some ethical issues regarding respect for wildlife (Myers 2014), which makes for great discussion. The Butterflies of Washington field trip is popular with students, as it allows students to capture and examine butterflies up close before releasing them, whereas other field trips that include birds may not have the same kind of enthusiasm, even though they may be watching some spectacular sights.

Educators need to plan lessons for multiple teaching and learning styles, and allow some time for inquiry. Facilitators should be wary of over structuring their lessons while in the field (Ballantyne and Packer 2002; DeWitt and Storksdieck 2008). Students are often frustrated when not allowed more choice to partake in inquiry, especially when visiting a new area, which may result in negative perceptions of the trip, and less favorable views reserved for the subject matter (DeWitt and Storksdieck 2008). Time allowed for inquiry allows students to find and satiate their desire for discovery (self-motivated learning) (Dohn 2011). While getting students out of doors in an atypical setting may help provide for optimal engagement, allowing for students to immerse themselves in the new environment allows nature to be the teacher (Simpson 1999).

Encouraging inquiry can be challenging for facilitators, as they may not be prepared to explain everything that students may find and be curious about. However, this may spur the students to search for answers to their questions themselves.

Longer field experiences have greater impact than shorter trips on environmental behaviors and attitudes (Dillon et al. 2006). In addition, one time experiences were not as effective as periodic exposure (Haluza-Delay 2001). This makes it advantageous to employ areas that can be easily visited again, whether by students on their own or as another class trip. Repeated visitations also influence positive long term impacts (DeWitt and Storksdieck 2008). Unfortunately, due to the time restraints on the BIOL 180 curriculum, students are only required to attend one field trip, and therefore, do not benefit from repeated visitations.

Lessons in more local, easily reached areas also help to break down the human-nature dichotomization – the common perspective that nature is a pristine place where humans aren't, that it doesn't exist where the students live (Haluza-Delay 2001; Higgins 2009; Russell 1999). One-time visits to spectacular, remote places may contribute to this perception. How to teach an urbanized population is a challenge of many environmental educators (Russell 1999). As engaging and inspiring as remote wilderness areas are, educators would do well to seek the value in local parks, ditches, ponds, etc. The breakdown of the human-nature dichotomization is one goal that field trips like Urban Birdin' and Microworlds on a Macro Campus (see Appendix) seek to accomplish.

The use of worksheets, note-taking and reports were unpopular with students and did not seem to contribute to short-term learning (Ballantyne and Packer 2002; DeWitt and Storksdieck 2008; Dillon et al. 2006). This prompts educators to evaluate their field materials beforehand, and design materials that aren't the central focus of the trip. McManus (1985, cited in DeWitt and Storksdieck 2008) made several recommendations for ways to turn worksheets into more effective learning tools in a museum setting (and by extension several field trip settings).

Worksheets should
(a) encourage observation
(b) allow time for observation
(c) refer to objects rather than labels
(d) be unambiguous about where information might be found
(e) encourage talk among group members.

Behrendt and Franklin (2014) add that worksheets become more effective when one worksheet is given to a small group. Students are then able to make more observations and interact with each other more frequently in discussing concepts and observations. Simple worksheets, such as fill-in-the-blanks, become a quest for the one right answer rather than exploring and participating in the activities.

In regard to this advice, I wish to share several examples from my own field trips.

- One activity performed during the Forest Ecology trip involved a scavenger hunt for the eight species of ferns along the Twin Falls trail. A desired outcome was that students took note of minor differences which would force them to look at things more closely (useful for troubleshooting in other arenas in life). Additionally, in fall, when the field trip is typically performed, the students would not be able to find the two deciduous species, allowing students to see that one visit is not enough in order to claim to know an area. This scavenger hunt, however, never engaged the students, and I felt passive resistance to the activity. While the activity was meant to focus their attention during the walk, many students (having never been on this trail before) felt that it was obstructing their ability to observe things that caught their interest.
- During the walk to collect water samples for the Microworlds on a Macro Campus field trip, a worksheet is provided for students to note their observations to better inform their hypothesis made about microorganism habitat. When reviewing the worksheets, a common pattern is that students take detailed notes at the beginning, followed by notes becoming sparse as the walk continued.
- When creating species lists during the Urban Birdin' field trip, the students originally wrote down the names of species as they were encountered. It has proved much more effective to provide a list of species that have been seen in the area explored, so students can simply circle the species, thereby reducing concerns about misspellings and time spent writing the list – the students have more time to enjoy the birds.

These examples illustrate how over-structuring lessons in the field can lead to students became disengaged in the activity. While there were credible goals behind the worksheets and activities, students felt that their desire to engage in inquiry was more important. Allowing the students more time to observe and explore the subject at hand typically resulted in more engagement and questions.

Risks. Inherent risk is not unique to outdoor education; every facet of life possesses its risks for physical injury. However, it is the facilitator's responsibility to ensure participant safety. The facilitator should not only have advanced skills in the subject matter being taught, but should also possess an advanced level of skill in decision making and judgment (Brown 1999). Decision making, judgment and risk management become different when in a group. Schumann et al. (2010) and McCammon (2004) found several factors that influenced risk management in avalanche terrain, but these can extend to many, if not all, outdoor education environments. It is important to take the weather forecast into consideration, especially in certain environments (snowshoeing and avalanches, pelagic trips and storms, dry country walks and heat, etc.). What McCammon (2004) called the "scarcity factor" refers to whether someone was in the area before the group – is there a trail already present? A trail or beaten path indicates that people have already been there; it is not uncharted territory, and gives a sense of safety. As participants and/or the facilitator visit an area repeatedly, familiarity with the terrain and other hazards increases, though this does make their dangers less present. The presence or absence of a leader also affects a group's decision making, as well as the presence of other groups or the number of people in the group – safety in numbers, the ability to draw on skills of group members, or sending group members to get help in case of an emergency – these may cause the group to take more risks than they would if they were alone (risky shift/group shift phenomenon) (Brown 1999; Myers et al. 1970; Wallach et al. 1964). A group's rigid commitment to completing course goals can place participants and the facilitator in danger – always evaluate the situation and be comfortable with ending the lesson early if conditions are not favorable. Facilitators should maintain an awareness of these factors and their influence on judgement and decision making in outdoor areas. It is imperative that they are made aware of them, as well as practice a group risk assessment where all students fully participate, so that participants are more prepared to act if an emergency should occur. The utilization of multiple facilitators or assistants (co-leaders) is another method to manage risk (Vernon 2011).

It is best practice to develop a risk management plan for field experiences (Brown 1999). This includes identification of potential hazards and risks, as well as evaluating their potential frequency and consequences. This should be performed before any trip with participants takes place, ideally during a scouting trip. Of the risks identified, adjustments can be made to ensure the greatest safety with a little compromise to the potential benefits (Brown 1999). The risk control methods include retention (for low probability or low consequence risks), reduction (employment of safety equipment and other measures to reduce probability of risk), avoidance (for certain environmental conditions), and transference (for infrequent, but potentially catastrophic, risks – often addressed through the insurance and liability waivers) (Brown 1999). Additional considerations in a risk management plan would be carrying first aid kits and knowledge of how to use the equipment inside, knowledge of nearest medical facilities, evacuation approaches, and individual risks (such as allergies to insect stings, etc.) – the reader is encouraged to review Brown (1999) for additional information.

While I like to push the comfort zone of the students on my field trips, safety is a concern to me, and I actively avoid situations that I feel are unsafe. Before each field trip, I make sure to know the location of the nearest hospital and where the nearest spot is that receives cell phone reception, should the field trip take place in an area where service is limited. Potential risks are discussed at the beginning of the trips, and appropriate actions are discussed. For example, students are told how to detect, avoid, and safely watch rattlesnakes when we travel to eastern WA. During the Wintering Birds of the Skagit Valley field trip, areas that are frequented by hunters are generally avoided to prevent accidents from occurring. While I may take more risks when on my own, I trust my previous experience and skills, and therefore err on the safe side when it comes to students, whose previous experience and skills I know nothing about.

Abilities of the Facilitator. The role of an educator varies immensely with the activity. The educator may take on the role of facilitation in reflection, a catalyst for interest and engagement, a mentor or coach for acquiring new skills, and being an honest assessor of learning (Itin 1999; Merriam et al. 2007). While the facilitator may take on many roles, these roles should be more equal to the students' role in the program. Rather than the instructor lecturing and taking control of the course, the participants, being self-directed learners, should be given more power in direction of the course.

Hobbs and Ewert (2008) found that participants valued attributes that related to the facilitator's authenticity and interpersonal skills. This includes honesty, integrity, enthusiasm, ability to articulate program goals, and holding participant interest at a higher level. These personal characteristics enabled participant trust in the facilitator and resulted in more complete engagement in the program. Positive memories are often associated with a well-organized, knowledgeable, humorous (Hoad et al. 2013), and caring instructor who carries respect for the students as adults and learners (Merriam et al. 2007). A course is also positively remembered when the facilitator takes the time to seek out, create and distribute relevant and useful course materials; these may include handouts, list-making, etc. aiding in memory and recollection (Merriam et al. 2007). Participants' worst learning experiences often include the opposite: an arrogant or showboating instructor with little respect for the participants, poorly delivering irrelevant content and materials (Merriam et al. 2007). The enthusiasm of the facilitator cannot be understated – students often come away with more positive attitudes toward the subject matter and learning because of a highly engaging and enthusiastic facilitator (DeWitt and Storksdieck 2008) – they see someone who is genuinely excited about the subject and thinks that sharing it is fun. Facilitator knowledge, skills, and judgement were also valued. Similarly, Shooter et al. (2009) found that three leader attributes, related to character, were important to establish trust: ability (technical and interpersonal), benevolence, and integrity. This trust positively influences learning, cooperation and group performance, and affects curriculum outcomes. With trust, learners should be willing to take risks and be open to new ideas and experiences (Merriam et al. 2007), whether that is an activity they have never performed and failure is a possibility, or honestly sharing their perspectives during a group discussion.

The limits of many teachers/instructors are understandable – time, resources, motivation, and stamina. However, I stress that the instructor should hone their skills and knowledge, especially in groups where that instructor is a newcomer. Successful experiences depend on facilitator preparation (Alagona and Simon 2010; Ballantyne and Packer 2002; Courtney et al. 2014; Dillon et al. 2006; Fox 2008; Hoad et al. 2013; Hobbs and Ewert 2008; Myers and Jones 2004; Shooter et al. 2009). Knowing the area to be explored and itinerary, and possessing the ability to answer questions will instill trust in the students, which is important in influencing outcomes (Shooter et al. 2009).

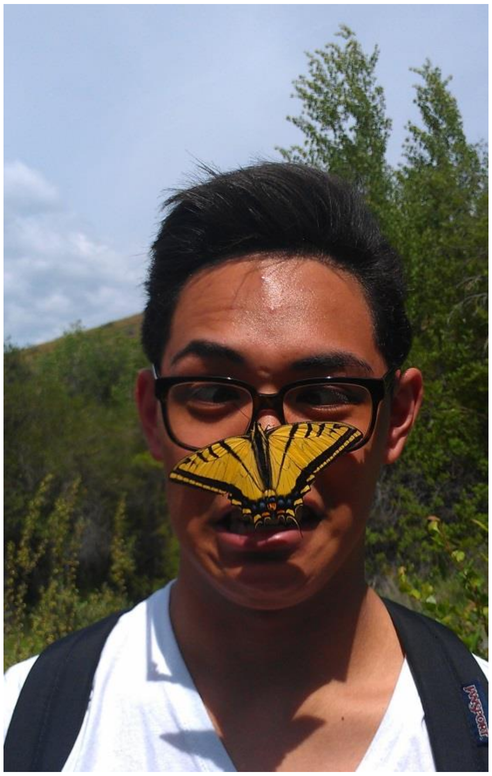
Scouting trips are needed to evaluate areas of potential use for lessons and activities (Myers 2014). The instructor must familiarize themselves with the area(s), both to plan lessons and identify potentially hazardous situations. For example, when the University of Washington introductory biology field trips travel to eastern Washington for butterfly field trips, a preliminary lesson on detecting and reacting to rattlesnakes is critical. During the Wintering Birds of the Skagit Valley field trips, scouting trips were able to identify areas that were heavily used by hunters - useful information in avoiding potential use conflicts or accidents. Consulting WDFW hunting seasons can also help in this effort. In addition to providing for logistical foresight, scouting also places the teacher in the role of the student. It is suggested that the teacher try some of the activities themselves to gauge feasibility in a potential field trip area as well as to improve instructional practice (Courtney et al. 2014).

Humor. Research shows that positive emotional mood is important to learning (Immordino-Yang and Damasio 2007) - humor can serve to create such a positive mood and emotionally engage students. There are a couple of recommendations that Hoad et al. (2013) suggests when using humor during experiential education, as using humor carries risk if used inappropriately. First of all, avoid using humor that is planned or forced – students can recognize this, and it may turn students against the facilitator emotionally. While it may be a tall order for a facilitator, an effective facilitator will be able to monitor the situation for a humorous opportunity and play off of it (see photos below). There have been times, however, where I have recognized a particular moment where a particular joke regularly works; being authentic and not sounding rehearsed, or at least acknowledging that it was forced, can help here. This can also include the facilitator having a sense of humor about themselves, which helps makes them appear more "human" and accessible to the students.

Secondly, remember the variety of forms of humor and difference in sensitivity between individuals. Hoad et al. (2013) recommends that a facilitator focus on positive humor and refrain from negative humor. Positive humor can involve such situations as informal joking, laughter in response to incongruity and problematic moments, storytelling, humorous interplay that challenges hierarchical relationship patterns, and shared empathetic laughter. Negative humor includes such examples of disparaging comments, sarcasm, mockery, ridicule, etc. Humor is specific to the individual – there are no concrete definitions on what constitutes positive from negative humor.

Humor is an important variable that affects memory and comprehension (Hoad et al. 2013). Rather than forgetting a particular lecture that gets lost among other facts learned throughout the lesson, a memory associated with humor lends itself more to the affective domain rather than cognitive, but remains linked to the factual knowledge – it becomes unique from other cognitive memories.

A forest service ranger continues giving his winter ecology lesson after falling backwards in the snow, much to the amusement of the participants.



A butterfly on the nose provides an up close and humorous encounter!

Reflection. Experiential education is often defined with a component of reflection; that is, reflecting on what the student has experienced during that lesson (Bass 2012; Behrendt and Franklin 2014; Colvin and Tobler 2013; Hoad et al. 2013, Higgins 2009; Itin 2009; Kolb and Kolb 2005; Millenbah and Millspaugh 2003; Simpson 1999). Mere activity does not constitute experience and learning (Millenbah and Millspaugh 2003). Incorporating time for reflection, either by allowing for time during the actual lesson itself or requiring the journaling of one's thoughts, allows the student to think about what they may have never experienced before, how that experience has compared to previous experiences, and how their experiences may have altered or challenged their current views on biology, learning or on broader horizons. Students can reflect on the failures as well as the successes. A failed field activity that results in the students not witnessing the intended result (a real possibility due to the stochastic nature of the field) can be viewed as a learning and reflection opportunity.

The facilitator can play an important role in framing reflections by asking motivating questions. As mentioned previously, reflection can take the form of group discussion, reflective journaling, etc. For critical reflection to be more effective in curricula, student reflections must be made accountable; this can be done by sharing with another student, or by periodic review by the facilitator, where the facilitator can look for reflections related to content and learning objectives. In BIOL 180, I do not see the students after the field trip – any reflection that I can take part in must occur during the trip. Generally, I save this for group discussions at the end of the trip, where I often pose questions that ask students to compare the experiences they've just had with others. Reflection may continue for them well after the field trip, but I am not privileged to know of it.

Assessment. Because of the varied nature of experiential education, assessment can be difficult. Assessing the performance of a student is no longer as simple as determining if they gave a correct answer or not. There must be other ways that students can demonstrate that they have learned the material, and more importantly, apply it outside of curricula and to novel situations. There are varieties of assessments that educators can and should use, given the individualized style of experiential education, to gauge the learning of students in a program (Millenbah and Millspaugh 2003). Reviewing journal reflections, one-on-one interviews, simulations, product assessment (e.g. written papers), essay exams, performance tasks etc. are some ways that a facilitator can evaluate a student's learning involving experiential education, depending on the topics covered (Forrest et al. 1976 – cited in Millenbah and Millspaugh 2003). Performance tasks are especially useful for assessment of learning in experiential education – a student being able to perform tasks in the field to satisfaction and explaining the many parts of the activity demonstrates their understanding of a method. Another useful assessment tool to evaluate student learning is a rubric which is then applied to rate student products, in which the instructor defines levels of proficiency that translate into a grade (Millenbah and Millspaugh 2003). Provided at the beginning of the course, students can self-assess their learning and performance during and after an experience.

In the field, student participation can be monitored to evaluate engagement. Do students stop relying on the facilitator to find birds/butterflies/organisms of interest? Do they start asking more questions than they are asked? Do they take the lead on the trail? To gauge student understanding of the material, the facilitator can take advantage of new areas, and ask the students to analyze the new landscape from the aspect of the topic being covered or topics already covered. For example, after observing and discussing several components of forest ecology, students are asked to analyze new forest patches regarding past disturbances, age of the stand, future composition of the stand, etc. What components of the landscape are influencing their predictions (see Forest Ecology lesson plan in Appendix)?

The students of BIOL 180 are required to complete a field trip evaluation upon completion of the trip. While administration uses these to assess participation from the student, they can also be used to assess the value of the trip. How much did the students learn? What did they experience? Did they enjoy the experience? The field trip leader also has access to these evaluations. Through the evaluations, the leader can identify weaknesses in the trip or their teaching methods/style and work to improve them.

Conclusion

Incorporating experiential education, and utilizing the methods above to increase its chances of success, should be seen as a valuable supplement to traditional classroom curriculum. The benefits of experiential education include increases in test scores, cognitive, and affective gains, and increased engagement and interest in learning – resulting in lower dropout rates (Freeman et al. 2014). The financial potential in tuition savings from decreased dropout rates is also considerable, given that 1/3 of enrolled college students intend to major in STEM (Science, Technology, Engineering and Math) fields (Freeman et al. 2014).

Just getting students outside isn't enough. The curriculum must ground the students in the place being experienced and incorporate insights and lessons from other disciplines; such is the true strength of field experiences. Field experiences provide the opportunity to break down barriers of different disciplines that a traditional classroom may appear to keep separate (Alagona and Simon 2010). Out in the field, one can draw on not only the ecology of an area and the biology and adaptations of the organisms found within it, as would be standard protocol of a typical biology field trip, but it may also incorporate historical land use by people, socio-political regimes that influence land use, artistic and literary inspiration, and math, to name just a few. Such integration of interdisciplinary concepts invites a more holistic learning experience for the student, a central aim of environmental education.

Even though the many benefits and praises of experiential education have been demonstrated, itis not without its limitations (Millenbah and Millspaugh 2003). The logistical limitations, from budgets to time, are plentiful, as discussed above. Experiential education is often more expensive than traditional forms of education, such as lectures (but they needn't be, if employed within the curriculum creatively – utilizing proximate habitats or requiring students to make observations outside of class time, for example). Educators must consider the administrative and material support needed (Acknowledgment of Risk and Hold Harmless forms, gear, vehicles, consent, etc.) for such methods to be successful. Experiential education is also more time consuming than information assimilation methods, and therefore, fewer topics are generally introduced within the short period of a course, with the tradeoff that students have a much deeper understanding of, and higher motivation toward, those covered topics than those students who were just lectured then tested on them. Arguably a balance of such depth and breadth is germane to college education. In addition, due to the stochastic nature of many outdoor teaching environments, there is the real possibility of failure in an activity, with the participating students not seeing the final intended result – although this can be seen as a reflection and learning opportunity (Millenbah and Millspaugh 2003). Careful planning and scouting trips are therefore crucial for success in experiential education.

While we, as educators, may want our students to perform well in the course, we also want students to enjoy the experiences provided for them. This goes beyond the use of the experience as a method for increasing cognitive gains that will assist students in the course and academia.

We also want them to enjoy learning and desire to continue learning, enabling them to become lifelong learners (DeWitt and Storksdieck 2008; Kolb and Kolb 2005; Sibthorp et al. 2011). In this regard, it has been encouraging when I receive student emails asking for directions back to the areas where we studied a particular subject, or where other areas might be closer to their residences where they can find more of the field trip subject matter. Students in general have rated experiential education portions of courses in high favor, stating they were more relevant and applicable to their personal lives and current work situation(s) (Millenbah and Millspaugh 2003). Most students report that the field trips in the University of Washington's introductory biology course as the best part of the course (see Example) (S. Freeman, pers. comm., May 18 2015). In addition, educators have also reported that it has enhanced their teaching experience (Millenbah and Millspaugh 2003).

Final Thoughts

Without the field trips, the concepts students learn in biology classes would likely just remain in the realm of the classroom, to be degraded or forgotten after the class ends. By demonstrating otherwise, the students will continue to observe the biological concepts they gained in the world around them. It is anticipated that by connecting the students' lessons to the world that they experience, they will be inspired to continue biology, and recognize that biology does not reside only in a lab or classroom.

From personal observations, evaluations, and conversations with other field trips leaders and program coordinators, it appears that the students value the trips. At the beginning of a field trip, some students may express frustration about their requirement to attend a field trip, given the amount of responsibilities on their plate mid-way through the quarter. Midterms, other homework, readings; this anxiety is understandable. However, at the end of the field trip, many students seem to have been happy that they took the field trip, and many of the evaluations reflect this impression. For a few select students, the field trip may have been life-altering, such as influencing them to change majors, while for a few, they may have perceived to have gained nothing from the field trips; but the majority of the students report that they had genuinely enjoyed the field trips, and made connections to the curriculum (C. Spencer, pers. comm. May 14 2015). Upon completion of the course, most students say that the field trip was the best part of the course (S. Freeman, pers. comm., May 18 2015 and C. Spencer, pers. comm. May 14 2015).

There is interest within the biology administration to perform a survey in the future that attempts to assess long term impacts of the field trips on students (C. Spencer, pers. comm. May 14 2015). Even lacking that, however, there has been some indication of long term impacts. For example, the Burke Museum typically acquires 8-10 new student volunteers (who had been in Biology 180) every quarter, because of the field trips there (C. Spencer, pers. comm. May 14 2015). It has also been encouraging that some students have sent emails to their field trip leaders after the field trip to ask about sites where they can continue to study the topic they had learned about on their field trip.

This is one example of how experiential education can be incorporated into entry-level college biology curriculum. However, the way the University of Washington biology course employs experiential education has its limits, as many experiential educational methods would in a course with hundreds of students – it is my view that this is likely the most efficient way of doing so. The trips are typically only day trips, with occasional overnights. Students are only required to attend one trip, so repeat exposure is not achieved. Pre-trip and post-trip activities are not performed due to time constraints. These limitations may be more easily met by a smaller class at a community college, for example, although these classes may face other challenges, such as funding and transportation.

Many of the components of a successful field trip have been incorporated into my own field trips that I lead for the University of Washington. I now try more often to relate what the students are experiencing to their previous experiences, and to give them a real sense as to why they are learning what they're learning. Worksheets have been modified to include minimal writing and more questions that encourage observation. And this has spurred motivation to try for more difficult field trips, such as overnight experiences or purely inquiry-based trips.

In the appendix, I have offered lesson plans of the field trips that I have led for BIOL 180. These include discussions the students and I might have during the trips, the sights we are likely to see, the places we visit, and the activities performed. These are not all-encompassing, of course, as surprises may trigger unplanned discussions. It is my hope that other educators will find the following lesson plans helpful in creating their own field trips for their students. Experiential education offers many benefits to reap, and students that take part in the method will gain a much deeper understanding of the subject and other components that interact with it.

Through my literature search and reflections on my own field trips, I am motivated to design new field trips, expose myself to learn new subject matter that can influence those trips, and connect with others that practice experiential education. After honing my skills as a facilitator of experiential education, I plan to offer my services to other professional institutions and organizations that utilize experiential education, and where I can reach and affect more people. This may include universities, community colleges, public agencies (i.e. the U.S. Forest Service), and education centers (such as the North Cascades Institute). By these means, I will use my skills to help people connect with the outdoors, and truly enjoy their learning experiences in it.

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Appendix – Field Trip Lesson Plans

Lesson Plan: "Microworlds on a Macro Campus"

Objectives:

- Students satisfy their biology field trip requirement.
- Students gain an appreciation for the world they cannot see
- Students understand how microorganisms impact their daily lives and why they are important to study
- Students gain practice at creating hypotheses and using microscopes

Location: University of Washington campus

Time frame: 4 hours. At UW campus, the walk to collect samples takes about 1 ¼ hours.

Time of Year: May be performed any time of year – provided there is an adequate amount of sites with water.

Equipment:

- Vials for collecting water samples on walk
- One microscope for each student (lab)
- Microscope slides and cover slips (lab)
- Pipettes for transferring samples from vials to microscope slides (lab)
- (Optional, but highly recommended) Computer + projector + internet connection for showing videos of microorganisms

From meeting place: Discuss itinerary, purpose and goals of the trip.

At first site, discuss:

- What roles microorganisms play in the food web (energy transfer)
    - Decomposers
    - Producers
    - Consumers
- What factors are important to aquatic microorganism habitat
  Some examples:
    - Decaying organic matter present (decomposers)
    - Amount of available sunlight (photosynthesizers/producers)
    - Permanence of the habitat (chance for colonization/establishment/stability)
    - Volatility of the water source (ease of movement for motile species)

In addition, discuss the hypothesis activity. Have students make a hypothesis that answers "What is the most influential factor in determining microorganism diversity at our sites?" (consider examples above). Taking notes about each site will help influence their hypotheses and predictions (see worksheet example for suggested template).

Continue to each site, and analyze each site for factors that are important to aquatic microorganism habitat. Contrast each previous site with the current one.

A brief description of each site comprising the UW campus trip:

> Site 1 (47.6526, -122.3092): A garden pond feature within the medicinal herb garden. This is where the introductory discussions are held. Here, students are asked if they expect the same organisms to be found in the litter as at the surface. Two samples are taken here; one from the surface and one from the leaf litter to help answer this question. This pond has lots of organic matter, moderate sunlight, still water and is a permanent water source.
>
> Site 2 (47.6535, -122.3079): The Drumheller fountain. While there is a lot of water and sunlight, the sight is not permanent, although may be seen as long term. The university drains and cleans the fountain periodically. The fountain, when spraying, is not seen as a stagnant water source. The fountain does not have much organic matter in the form of leaf litter; however, the ducks may be seen as a source of organic matter (droppings) as well as a means of introduction of microorganisms from other sites.
>
> Site 3 (47.6541, -122.3085): Puddle on sidewalk: The trip always stops at the same puddle. It is the deepest and is therefore available for sampling longer than the smaller ones. Puddles are a good example of metapopulations, and by stepping in one and the other is a good demonstration of gene flow. However, the puddle is seen as an extremely chaotic habitat. It is ephemeral (dries up often), freezes over in cold weather, and has many physical disturbances (feet, bicycles, etc.). Because there is relatively little water, the temperature also fluctuates greatly. But, there is plenty of sunlight and decaying organic matter. After students see how much is living in the puddle, it is a good source of discussion for adaptations of microorganisms to survive extreme conditions.
>
> Site 4 (47.6557, -122.3056): The trip usually stops by a water fountain. While the site is typically not sampled (due to not finding anything through much sampling), it is still a good prompt to discuss the human body as a habitat for microorganisms, from the benign freeloaders to the detrimental, disease-inducing parasites, and mutualistic organisms that are critical to our immune system.
>
> Site 5 (47.6538, -122.2980): The lakeshore of Lake Washington. Similar to Site 1, the students are asked what differences they expect between the lakeshore and 50 feet out in open lake water. It is generally concluded that the lakeshore has much more organic

matter, with currents pushing floating material to the shore, with the lakeshore being a bit more stagnant than open water. Both sites share about equal sunlight, and the lake is certainly a permanent habitat.

Site 6 (47.6537, -122.2989): A rainwater runoff ditch. This site, while offering much decaying organic matter and receiving abundant sunlight, is dependent on rain. After a period of no rain, it dries up, leaving a grassy ditch – an ephemeral site. An alternate site during drier times is located across the dirt road, an extension of the bay that usually has a visibly oily film (47.6538, -122.2986).

Site 7 (47.6523, -122.2989): In order to gain a proxy sample for open lake water, the UW trip uses the canoe launch ramps that extend ~60 feet into the water. While students note that the lakeshore has more discernible organic matter, they note that the opacity of the water means there is fine organic matter distributed throughout the water.

After final sample has been collected:

Ask students to hypothesize what factor is most important to microorganism diversity at our sites. Students need to predict in which samples we will find the highest diversity of aquatic microorganisms and in which samples we will find the least, based on their hypothesis. These predictions will then be confronted by the data collected in the lab.

Back at the lab:

Microscope samples are prepared by placing a drop or two of a site sample onto a microscope slide, and then covered by a cover slip. The cover slip makes the sample 2 dimensional rather than 3 dimensional (easier to survey). Once each student has their prepared sample, they will need to be trained on how to use their microscopes.

Give them a sample for practice using microscopes with before data collection begins. During the UW trip, this usually is a sample of moss from a tree, driveway, etc., which has been dependable at producing water bears (tardigrades), preceded by a video that discusses water bear biology. This sample is usually prepared by soaking moss in water for at least a couple of hours beforehand, draining the excess water, and then squeezing the water out of the moss. The water than emerges from the moss should be laden with organisms that live in the moss.

Hint: Always have them start each sample at the lowest magnification; this allows them to have the widest field of vision (see the most things at one time). They can then use higher magnification to more closely inspect items of interest.

Data collection:

Samples will be surveyed one at a time, with all students viewing the same sample concurrently. This eases data collection and interpretation.

In order to achieve the goal of appreciating the diversity of the world they cannot see, it is important that students know more about the organisms that they are seeing. There are two videos on YouTube that I utilize for this purpose:

Life in a Drop of Water (https://www.youtube.com/watch?v=_cpBK2t0Yeo)

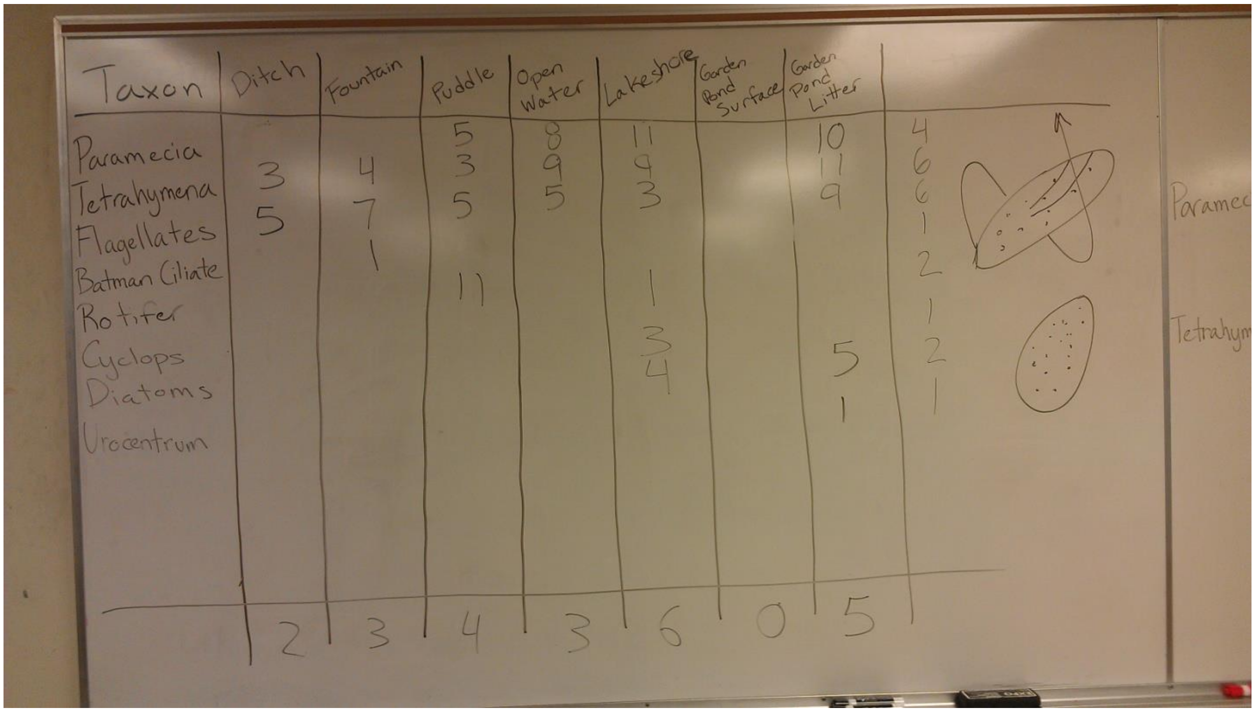
Diversity of Protists (https://www.youtube.com/watch?v=Ln69k7LyTsU).

1. When students encounter a new organism that has not been discussed yet, have them describe it for the rest of the class.
2. Confirm identification of organism.
3. Play section(s) of video(s) that show the organism and discusses its adaptations and behavior. This will help other students identify it if they have it in their sample as well, as well as learn about the organism's natural history.
4. Once there are no new organisms being seen, tally the number of students that are seeing each organism in that sample. This is a measure of relative abundance (a proxy).
5. Repeat steps 1-4 for each additional sample, until all have been surveyed.

Additional note: Not all organisms will be identifiable. In the case where there is an organism that is noticeably different, yet the ID cannot be found, have the students give the organism a name, so that data can still be collected.

End of data collection:

Total the number of discrete, identified organisms from each sample (the number of different taxon). These are the data against which they will test their hypotheses. Ask the students how their hypotheses faired against the data.



Example of totals at end of data collection<fix image contrast??>

End discussion:

Discussion on hypotheses, support by data, meaning of results, etc.

Discuss the limitations of their data and conclusions in making generalizations about all aquatic microorganisms.

Most common and least common taxon are a good introduction to specialists and generalists.

Ask the students why microorganisms are important to study:

Some examples

- Bottom of the food chain and decomposers
- Photosynthesizers (algae produce the most oxygen)
- Use in the study of genetics
- Importance to human health (detrimental [disease] and beneficial [immune system])
- Demonstration of biological concepts (useful for biology students!)

Assessment

To assess their understanding of biology course concepts, there are several questions that can be asked along the walk and in the lab. After stepping through a series of puddles, thereby connecting them, the students are then asked what has been helped in that process. Students with a grasp of metapopulations concept will answer gene flow or something similar. Likewise, many organisms are good examples of convergent evolution – filter feeders like Vorticella and Rotifers are good examples. The final discussion is a good time to assess their understanding and comprehension of the concepts of the field trip. Reviewing their worksheets is another way to check for engagement in the field trip.

Worksheet example

Biology 180 Microorganisms Field Trip Worksheet

Site	Description	Predictions/Hypotheses
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

How accurate were your predictions? Why might they have been inconsistent with what we actually found?

Draw 3 objects below

Describe how their structures might be adaptive for the environment where they were found.

Lesson Plan: " Urban Birdin' "

Objectives:

- Students satisfy their biology field trip requirement.
- Students are introduced to bird biology and ecology.
- Students identify, and learn about the natural histories of many bird species commonly found throughout the state.
- Students gain an appreciation for the resilient bird species that are able to adapt to human environments, and see urban areas as habitat for birds.

Location: Union Bay Natural Area, located east of the University of Washington Seattle campus. Best meeting place is the eastern parking lot at the Center for Urban Horticulture (CUH).

Time of Year: Any time of year, but trips taken during migration season (late fall or spring) are prime for discussions on migration.

Time Frame: Students meet in the CUH lot at 8:00 AM. Typical length of field trip lasts four hours.

Equipment: Binoculars for each student, as well as a list of potential bird species to be seen in the area.

Guide: It is advised that the field trip leader carries a guide, but not that each student have their own guide. In addition to the species list and binoculars, the guidebook is cumbersome. The field trip leader, by carrying a guidebook, can display each species as well as point to similar species.

Main activity: Creation of a species list – a list of species encountered.

- Provide a list of species previously seen in the area for easier recording – students can circle species observed.
- Report the totals from past field trips, and encourage the students to try and beat the record – a little friendly competition.

First lesson: Train students on how to properly operate binoculars.

Birds, lessons they exemplify, and related discussion questions:

Sexual dimorphism – why has natural selection favored different forms between the genders? Why are some species not sexually dimorphic?

Understanding that sexual dimorphism is a gradient, ranging from not at all, to modestly, to starkly. Sexual dimorphism may have evolved for very different reasons in each species.

Common birds that are strongly sexually dimorphic:

- Ducks, house finches, red-winged blackbirds, northern harriers, hummingbirds, American goldfinches, many others.

Common birds that are not sexually dimorphic:

- Crows, jays, eagles, swans and geese, many others.

Discussion of migration – why would a behavior so energetically demanding and with such complex adaptations have been selected for? How might it have started? What are the advantages of migrating? What are the strategies of being a resident species?

Some helpful, and amazing, stats to help fuel the conversation (from The Homing Instinct (Heinrich, 2014):

- Record holder for longest non-stop migration: The bar-tailed godwit flying across the Pacific Ocean from its breeding ground in Alaska to New Zealand.
- Manx shearwaters' (seabirds) ability to return to their breeding island after being transported thousands of miles away to areas they have never been.
- Research has revealed that many songbird migrants use the stars as a compass.

- Ability to navigate by detecting the earth's magnetic field – there may even be an adaptation in the eye that allows them to see the magnetic field.
- Could humans take advantage of this? Roman soldiers carrying swallows from their cities were used to transport messages quickly from scouting missions. The first tweet (Twitter joke)?

Additional questions:
Why would a male Bufflehead or American Wigeon, who take no part in the raising of the young, still migrate to Alaska along with the female? Why would he not mate with the female in the wintering range, and stay behind?

An exception to slow improvements:
The blackcap warbler has been increasingly wintering in the British Isles since the 1950s, after breeding northern Europe. Typically, this species winters in northern Africa. The number of blackcaps wintering in the British Isles has been increasing. Why would natural selection be favoring those birds that have the genetic predisposition to migrate to a region different than traditional routes?

Additional life history/adaptations as other birds are encountered.

Activities: These meet the objective that students observe and become familiar with bird research methods.

Birding by ear: Learning to identify birds by song and call.

Why is it necessary for someone studying birds to have this skill? Why aren't binoculars enough?

This activity is best performed at the beginning of the trip. Have the students close their eyes (more concentration on their sense of hearing) and listen for the bird vocalizations in the surrounding area for about 1 minute. Ask them to try and distinguish how many different species they are hearing (not name the species, simply state how many different birds they feel are vocalizing).

What are the differences between calls and songs? What are the purposes of a song (and who typically performs them)? What are the purposes of a call?

Upon conclusion: Discussion of species list created.

What are some limitations? What other data may have been collected?

Examples

- Abundance
- Locations observed (habitat associations)
- Behaviors performed by observed species
- Gender ratios
- Juvenile-adult ratios (more relevant for birds)
- Time of day observed
- Many others

Look at other species that can be found in the area and from other trips, but were not seen that day – can someone visit an area once, and claim to know it?

What might result from management decisions based on only this one day's species list?

Why are birds important to study?

Assessment

Note if all students are pointing out birds they are seeing, or if just a few students are consistently doing so. Involving students in discussions by asking questions, rather than lecturing, should also gauge engagement; the point of these discussions is more to elicit ideas than correct answers.

Asking students what their favorite sight of the day was is a good way to assess engagement and enjoyment.

Lesson Plan: "Wintering Birds of the Skagit Valley"

Objectives:

- Students satisfy their biology field trip requirement.
- Students are introduced to bird biology and ecology.
- Students identify, and learn about the natural histories of many bird species that spend the winter in Washington State.
- Students gain a respect and admiration for the physical feats (migration) that many bird species routinely perform.

Location: Sites along coastal Skagit County – see "Description of Sites" below.

Time of Year: While the trip could be performed from late November through mid-March, it has been most effectively executed after late January, after hunting season has ended.

Time Frame: Students depart from the UW campus at 8:00 AM. Field trip typically returns by 2:30 PM, but the field trip is scheduled until 3:30 PM to allow for traffic delays while returning to Seattle.

Equipment: Binoculars for each student. A spotting scope is very useful on this trip.

Guide: It is advised that the field trip leader carries a guide, but not that each student have their own guide. In addition to the binoculars, the guidebook is cumbersome. The field trip leader, by carrying a guidebook, can display each species as well as point to similar species.

Description of sites visited:

Visited in this order

Portage Creek Wildlife Area – Located in Snohomish County, this area is used as a good beginner's spot. Walking along the path usually reveals many blackbirds among the fields, and the row of trees usually produces many songbird species. The area is also known as a good spot for hawks – rough-legged hawks appear in winter.

"Big Ditch" – The adjacent fields are often used by trumpeter swans and occasionally snow geese. Virginia rails are dependable at calling back in response to their calls being played. On clear days during high tides, clouds of dunlin can often be seen in the distance.

Skagit Wildlife Area, Wylie Slough – this site is a good alternative to the Portage Creek Wildlife Area. Many songbirds and woodpeckers foraging among the brush and trees, and many ducks forage in the slow moving waters. Hawks are often seen as well. A popular hunting spot during hunting season.

Fish and Wildlife Snow Goose Preserve – During hunting season, this is the most dependable place to find the flocks of snow geese, as this sight is off limits to hunting. The small bay beyond the dike is usually graced by a resident kingfisher and herons, along with many species of ducks. There is a bald eagle nest in the trees leading up to the parking lot, where the resident pair is usually stationed, sometimes along with other raptors. During high tides, large flocks of dunlin forage in the agricultural field, and peregrine falcons and merlin can sometimes be seen hunting them.

Skagit Bay Jensen Access – A walk up to the dike produces great views of the bay, along with usually flocks of shorebirds, trumpeter swans, gulls, and ducks. This area is usually taken by hunters during hunting season.

Skagit Bay North Fork Access – Snow geese are often seen in the adjacent agricultural fields later in the season. Walking up to the dike, the views include Skagit Bay and Craft Island. Northern harriers are often seen cruising over the marsh. In the evening, short-eared owls take their place. This area is also good for producing American bitterns, but they usually need to be flushed from their cattail patches.

<u>First lesson:</u> Train students on how to properly operate binoculars.

Along with this first lesson, it is advised to give the students this disclaimer, to contextualize the field trip.

"We are chasing animals, and animals move. What was a productive site for the previous trip may not be productive for us. I cannot guarantee anything, but I guarantee we will see something."

Birds, lessons they exemplify, and related discussion questions:

Sexual dimorphism – why has natural selection favored different forms between the genders? Why are some species not sexually dimorphic?

Understanding that sexual dimorphism is a gradient, ranging from not at all, to modestly, to starkly. Sexual dimorphism may have evolved for very different reasons in each species.

Common birds that are strongly sexually dimorphic:

- Ducks, house finches, red-winged blackbirds, northern harriers, hummingbirds, American goldfinches, many others.

Common birds that are not sexually dimorphic:

- Crows, jays, eagles, swans and geese, many others.

Discussion of migration – why would a behavior so energetically demanding and with such complex adaptations have been selected for? How might it have started? What are the advantages of migrating? What are the strategies of being a resident species?

Some helpful, and amazing, stats to help fuel the conversation (from The Homing Instinct (Heinrich, 2014):

- Record holder for longest non-stop migration: The bar-tailed godwit flying across the Pacific Ocean from its breeding ground in Alaska to New Zealand.
- Manx shearwaters' (seabirds) ability to return to their breeding island after being transported thousands of miles away to areas they have never been.
- Research has revealed that many songbird migrants use the stars as a compass.
- Ability to navigate by detecting the earth's magnetic field – there may even be an adaptation in the eye that allows them to see the magnetic field.
- Could humans take advantage of this? Roman soldiers carrying swallows from their cities were used to transport messages quickly from scouting missions. The first tweet (Twitter joke)?

Additional questions:
Why would a male Bufflehead or American Wigeon, who take no part in the raising of the young, still migrate to Alaska along with the female? Why would he not mate with the female in the wintering range, and stay behind?

An exception to slow improvements:
The blackcap warbler has been increasingly wintering in the British Isles since the 1950s, after breeding northern Europe. Typically, this species winters in northern Africa. The number of blackcaps wintering in the British Isles has been increasing. Why would natural selection be favoring those birds that have the genetic predisposition to migrate to a region different than traditional routes?

Additional life history/adaptations as other birds are encountered.

Activities: These meet the objective that students observe and become familiar with bird research methods.

Birding by ear: Learning to identify birds by song and call.

> Why is it necessary for someone studying birds to have this skill? Why aren't binoculars enough?
>
> This activity is best performed at the beginning of the trip. Have the students close their eyes (more concentration on their sense of hearing) and listen for the bird vocalizations in the surrounding area for about 1 minute. Ask them to try and distinguish how many different species they are hearing (not name the species, simply state how many different birds they feel are vocalizing).
>
> What are the differences between calls and songs? What are the purposes of a song (and who typically performs them)? What are the purposes of a call?

Upon conclusion:

> Why are birds important to study?
>
> Mention of local Audubon Society chapters so inspired students can meet people with similar interests and continue birding.

Assessment

Note if all students are pointing out birds they are seeing, or if just a few students are consistently doing so. Involving students in discussions by asking questions, rather than lecturing, should also gauge engagement; the point of these discussions is more to elicit ideas than correct answers.

Asking students what their favorite sight of the day was is a good way to assess engagement and enjoyment.

Lesson Plan: " Forest Ecology "

**Note – as of March 2015, the Twin Falls trail (see location below) is closed due to a landslide, albeit small, and the trail is being evaluated for a reroute. The sections that are closed off contain some of the biggest trees along the trail, and good places to talk about landslides. Therefore, the forest ecology field trip is not currently being led. A stand-in trail is being sought, but the trails explored thus far have been unsatisfactory.

Objectives:

- Students satisfy their biology field trip requirement.
- Students are introduced to the biological and physical processes of a typical Western Washington forest.
- Students identify and learn about many of the common species in a Western Washington forest, and their adaptations to the northwest ecosystem.

Location: Twin Falls trail, located in North Bend. Starting location is at the Twin Falls trailhead located off exit 34 on Interstate 5.

Time of Year: This trip can be performed any time of the year.

Time Frame: Students meet in the CUH lot at 9:00 AM, and generally return by 3:00 PM.

Equipment: soil probe, plant field guides

Forest Ecology Concepts:

An area that is used to employ this lesson plan should have many, if not all, of the components listed below to exhibit to the students and impart the lessons of Western Washington forest ecology.

Old growth Western Washington forest:

Defined by four components –

- Big, old trees
- Snags – i.e. standing, dead wood
- Nurse logs – downed trees
- A heterogeneous canopy – an upper canopy made of late successional species (western hemlock, western red cedar, etc.) with younger trees of the same species below them. An upper canopy of Douglas fir, a pioneer species, with an understory of hemlock/cedar does not constitute the heterogeneous canopy the helps define old growth.

- Contrast with the structure of an old growth ponderosa pine forest in Eastern Washington.

Stages of succession:

In this explanation, we start after a disturbance has removed or altered a large patch of forest in a significant way, allowing abundant sunlight to reach the soil level.

Pioneer species – Come in after a disturbance, tolerant or dependent on high light levels. Red alder, Sitka spruce and Douglas fir represent pioneer species along the Twin Falls trail.

Shade-tolerant species – Are tolerant of the low light levels beneath the canopy of pioneer species. As the pioneer species die, they are replaced by the shade tolerant species. Western hemlock and western red cedar represent shade-tolerant/late successional species along the Twin Falls trail.

As the shade tolerant species grow older and larger, their offspring can tolerate the low levels beneath their parents, in contrast to the pioneer species. When shade-tolerant species replace a canopy of the same species, the canopy species composition will remain the same. This is referred to as a climax state. It will remain until the next disturbance resets the succession timeline.

It is important to note that shade-tolerance is a gradient. Big-leaf maple, for example, is more shade tolerant than red alder, and therefore can take advantage of disturbance of a smaller scale than the alder. In addition, while Douglas fir may be considered a pioneer species, it can tolerate the shade beneath a canopy of alder and maple.

Disturbances:

It is important to note that disturbances vary in size and intensity, and they may interrupt the stages of succession outlined above at any time.

- Landslides
- Windthrow
- Fire
- Disease/Insect Attack

When encountering an area in the stages of early succession or another sign of past disturbance, ask the students what could have happened? What evidence would they look for to support the hypothesis of any one of the disturbances listed above?

Climate Change and the Hydrological Cycle:

Standing on the shores of the South Fork Snoqualmie River is a good place to discuss the hydrology of the Pacific Northwest.

Using Figures 1 and 2, discuss the seasonal behavior of our Western Washington rivers. How do we expect the seasonal behavior to change as the climate changes? How might the landscape that we see now change?

Activities:

Birding by ear: Learning to identify birds by song and call. This gives students something to concentrate on during the walk.

> Why is it necessary for someone studying birds to have this skill? Why aren't binoculars enough?
>
> Have the students close their eyes (more concentration on their sense of hearing) and listen for the bird vocalizations in the surrounding area for about 1 minute. Ask them to try and distinguish how many different species they are hearing (not name the species, simply state how many different bird species they feel they are hearing).

What are the differences between calls and songs? What are the purposes of a song (and who typically performs them)? What are the purposes of a call?

Differences between early and late stages of succession:

Upon transitioning from one stage of succession to another, stop and ask the students what changes they notice. For example, the transition from an early successional forest to second growth forest is rapid on the Twin Falls trail. When asked about what the students notice, their answers may include (how the later successional forest differs from the early successional forest):

- It's darker (in late autumn through early spring)
- You can see farther (less understory growth)
- More ferns
- It's colder

Why do these stands differ in this way?

Fern Scavenger Hunt:

According to the Washington Native Plant Society, 8 species of ferns can be found along the Twin Falls trail. A two sided handout (Figure 3) was made with distinctive points of each species. Groups can be made to create competition, and a prize can be awarded to the winner(s).

Ferns are a great discussion topic to talk about the evolution of plants – they reproduce with spores like many primitive plants like the Bryophytes (mosses), yet are vascular like many flowering plants. Given the diversity of life histories and survival strategies by the species along this trail, they also make a great topic on biodiversity, and generalists vs. specialists. Two species, bracken fern and lady fern, are deciduous, and will not be found in the winter months.

**Note – this activity was not met with the interest or enthusiasm that was hoped for. It has been postponed for now, but may work with other groups in other areas.

Beneath the trees:

This activity gives students a chance to see the forest beneath the soil and to test a hypothesis that a landslide was the disturbance that reverted that stand to an earlier successional stage. This activity should only be attempted where appropriate (not in a state park or in areas of high usage, for example). It is recommended that the instructor prepare the site beforehand, as digging a soil profile can be time intensive.

Dig a pit about 2-3 feet deep with one side flat so as to view the soil as a profile within a more advanced successional stage. This soil profile should have the horizons typical of a soil that has not been disturbed, with several distinct horizons.

In an early successional stage stand, using the soil probe, take a soil sample. Looking at the soil sample within the probe should help confront the landslide hypothesis. If a landslide happened fairly recently, there would little to no transition between soil horizons – it would all be homogenously mixed. If there are distinct horizons, then the soil has not been disturbed recently, and a landslide is likely not the disturbance that set this stand back in succession.

**Note – a soil probe may or may not be feasible. It was not able to be employed along the Twin Falls trail, due to the abundance of rocks in the soil, preventing us from obtaining a complete soil core.

Other useful discussions:

The history of logging in the region, and its effects on wildlife, water, and composition. What disturbance do clear cuts emulate?

Assessment

After students have been informed of the disturbances and different stages of succession in western Washington forests, it is useful to ask students to examine the landscape as the group enters new patches of forest, especially when the species composition or terrain changes suddenly. Have them discuss what stage the forest stand might be in, predict what may have caused the change, and predict what the stand may look like in the future (some defined timeframe). A class that understands the material will be able to incorporate terms discussed and provided reasonable explanations based on observations.

Figure 1. Skagit River flow and precipitation

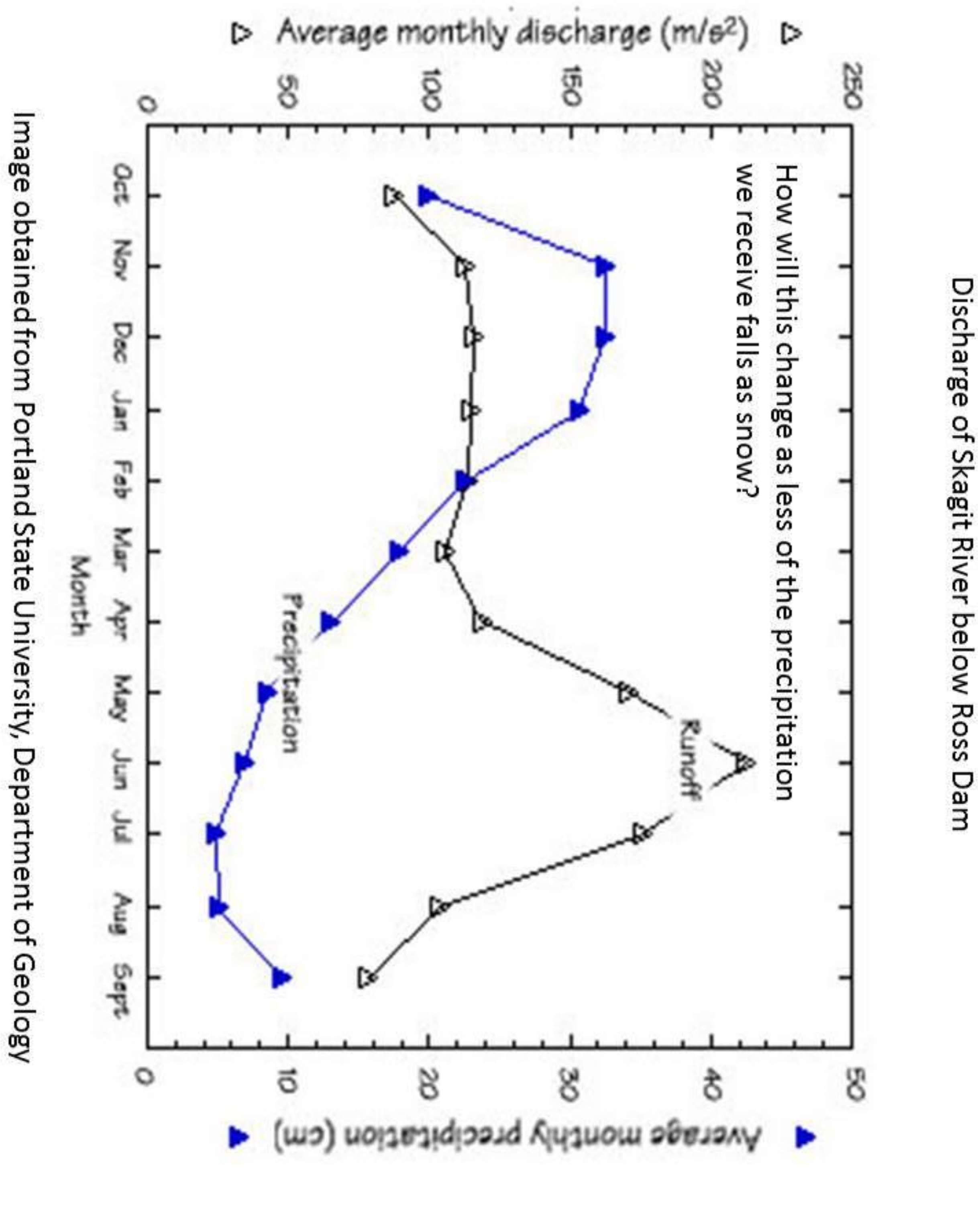


Figure 2. Precipitation regimes and seasonal river behavior

What does the current discharge suggest about our dominate water regime?
Is it susceptible to the effects of climate change?

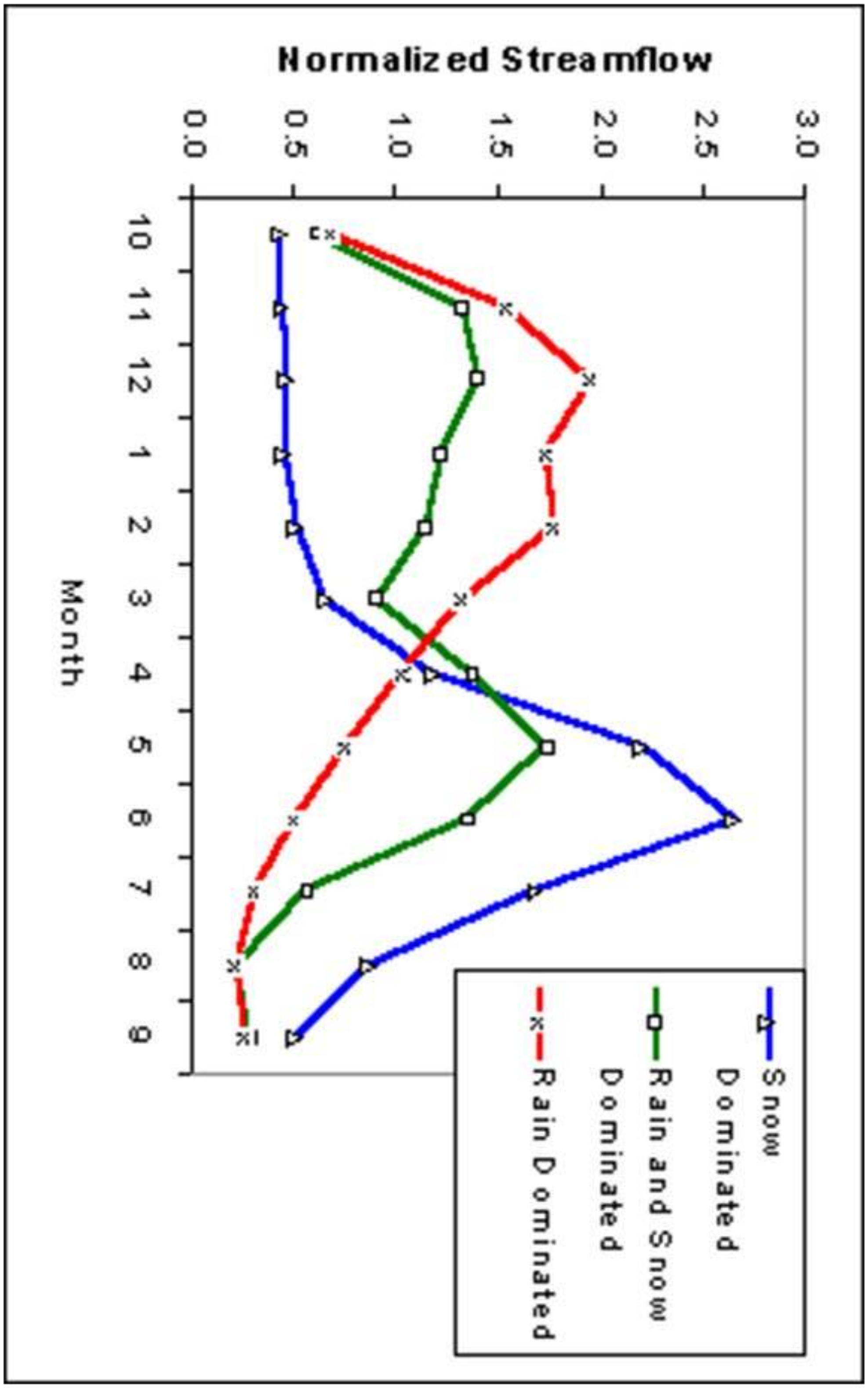


Image obtained from University of Washington, College of the Environment

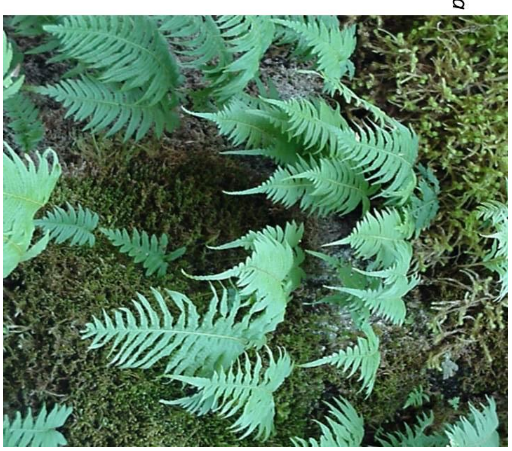
Figure 3. Fern scavenger hunt handout – two pages

Sword fern
Polystichum munitum
•Evergreen
•Large, abundant
•Erect leaves forming a crown
•Once pinnate
•Sharp toothed
•Basal lobe
•Moist forests

Lady fern
Athyrium filix-femina
•Fronds clustered, erect and spreading
•Large, tapering at both ends (diamond shaped)
•Moist to wet forests and clearings.

Deer fern
Blechnum spicant
•Evergreen
•Medium
•Leaflets attached across base
•2 kinds of fronds
•Moist to wet forests

Licorice fern
Polypodium glycyrrhiza
•Evergreen
•Once pinnate
•Often growing on deciduous trees and downed logs



Maidenhair fern
Adiantum pedatum

- Palmately branched
- Dark purplish-black stipes
- Blade at right angle to leaf stalk
- Shady, humus rich sites, often rocky forests. Cliffs and spray zones of waterfalls.

Spiny Wood Fern
Dryopteris expansa

- 3 times pinnate
- Broadly triangular
- 2 basal leaves much larger
- Stipes scaly at base
- Moist forests and openings, scree slopes

Bracken fern
Pteridium aquilinum

- Deciduous
- Large, solitary
- Triangular
- Hairy
- Many habitats, often weedy

Maidenhair Spleenwort
Asplenium trichomanes

- Small, firm, evergreen
- Purplish-brown stipes
- Densely tufted
- Prefers limestone/ calcium rich rocks as substrate
- Moist, shady, sheltered crevices

Lesson Plan: "Butterflies of Washington" - Spring

Objectives:

- Students satisfy their biology field trip requirement.
- Students are introduced to butterfly biology and ecology.
- Students identify, and learn about, many local species to their state and their life histories.
- Students observe and practice butterfly research methods.

Location: Umtanum Creek Falls trail – near Ellensburg, WA. Three habitats converge (sagebrush steppe, ponderosa pine forest, and riparian forest) along this trail, resulting in a diversity of butterflies, birds and wildflowers. If weather is not favorable for butterflies, the area can easily accommodate a bird and wildflower field trip.

Time of Year: May, with late May being more favorable for weather and diversity.

Time Frame: Depart UW at 7:00 AM. Approximate drive time to the trailhead is 2.5 hours. Bathroom stops at Snoqualmie Pass/Indian John rest stop. Typical return time around 6-7 PM.

Equipment: Butterfly net for each student, adequate supply of water, first aid kit, larvae beating sheet, fine-tip sharpie pens for marking demonstration, bags of candy bars for MRR example, viewing jars, envelopes for specimens, forceps for handling butterflies.

Additional preparation: Discussion of rattlesnake detection, reaction, avoidance, and observation. Make sure each student wears close-toed shoes and long pants.

Guide: Butterflies of Cascadia by Robert Michael Pyle. This is the most detailed and complete guide for the Pacific Northwest. Other field guides can be used for other regions.

Main activity: Creation of a species list – a list of species encountered.

- Provide a list of species previously seen in the area for easier recording – students can circle species observed.

First lesson: Train students on how to properly catch and handle butterflies.

Butterflies, lessons they exemplify, and related discussion questions:

Swallowtails and hairstreaks: convergent evolution and natural selection of defensive mechanisms (false heads, size [swallowtails])

Whites: Mullerian mimicry - include discussion of Batesian mimicry as well, and the differences between the two. If white butterflies are not aposematically colored (as Lyytinen *et. al.* 1999 suggests), what might be the advantage of being so brightly colored?

Blues: Sexual dimorphism - why has natural selection favored different forms between the genders? Why are some species not sexually dimorphic?

Puddling butterflies: Males gathering at damp earth for nutrient acquisition – a mating behavior where males gather salts and minerals not found in flower nectar to grow their spermatophores.

Phenologies and Resource Dependence: Climate Change Implications
Many butterflies are linked to larval host, nectar sources, and habitats. How might the advancement of climate change affect populations and habitats?

Additional life history/adaptations as other butterflies are encountered.

Activities: These meet the objective that students observe and become familiar with butterfly research methods.

Mark-release-recapture (MRR) studies:

Mark a couple of butterflies using a fine-tipped black sharpie. Use a larger butterfly for ease of demonstration and observation.

Discuss what insights can be gained by MRR studies.

- Population (abundance) estimates
- Longevity
- Movements

Demonstration (candy bar example): This is useful to demonstrate how a MRR study is performed, as an MRR study on live butterflies in a population is far too time consuming and labor intensive for a day trip, as well as discuss violations in the assumptions.

Equipment needed: 1 large bag, 1 black sharpie, and a population of miniature candy bars (about 6 per student).

1. Place candy bars in bag. Have each student "capture" 2 "butterflies" from the population. Have them mark each with a large black X, so that it will be easy to tell if that individual has been captured before.
   Assumption: All individuals have an equal probability of capture.
   Violation: Male butterflies are encountered more frequently, as females tend to hide from these amorous males.

2. Have students release their marked "butterflies" back into the population. Shake the bag to mix up the marked and unmarked "butterflies".
   Assumption: All marked individuals will mix evenly back into the population.
   Violation: Studies with Red-cockaded Woodpeckers showed that males marked with red bands were pushed to the edges of the population (shunned) because red is a coloration used in aggression in this species; individuals they encountered always thought the red banded males were being aggressive.

3. Each student will then "capture" 2 "butterflies" from the population. Take a tally of how many of those caught are marked (recaptured). Apply data to the Lincoln-Peterson Index, one of many indices used for population estimates. Get estimate for population.

   $N = Kn / k$ where N = the total population (what we want to estimate)

K = # of individuals marked on the 1^{st} visit
n = # of individuals captured on the 2^{nd} visit
k = # of recaptured (marked) individuals on the 2^{nd} visit

Assumption: Captured individuals have the same probability of capture as unmarked individuals.

Violation: Small mammals, such as mice, can learn to recognize that traps offer food, bedding and safety for a night, resulting in animals that have been captured before to be more likely to be recaptured.

4. How would intensifying our efforts affect the accuracy of our estimate? Typically, the higher proportion of the population that is marked, the more likely your population estimate will be close to the actual population abundance. Have students draw candy bars until they find two that are unmarked (double sampling effort). Mark them the same as in step 1. Repeat step 2.

5. Repeat step 3. How does the number compare to the first estimate?
   Assumption: Capturing/marking individuals does not cause them stress, and influence them to leave.
   Violation: Much more likely in open populations
   Assumption: Marking the individual does not cause an increase in mortality, whether that is due to stress or injury suffered during marking, or if marking increases visibility of the individual to predators.
   Violation: Toe-clipping in frogs used to be the way amphibians were marked (each frog would have a unique combination of toes clipped). It was later demonstrated that individuals suffered reduced longevity.

6. To demonstrate violations in the last two assumptions, select 2 marked individuals from the bag. Suppose they got stressed after being captured, that they were influenced to leave the population (toss candy bars behind you).
   Select two more marked individuals from the bag. Suppose marking made them more conspicuous to predators (eating these individuals usually draws some laughs).
   How would these violations affect our estimate of the population?
   -Our supposed K in our Lincoln-Peterson index would actually be less, and we would have less of a chance of recapturing individuals (as they no longer reside in the population).

7. Conclude by allowing the students to eat the rest of the population.

Pollard walk:

History of development of Pollard walk and why it's such a prevalent monitoring method.

- Easily trained
- Inexpensive
- Relatively low labor effort
- Easily repeated

The observer imagines they are at the back of a 5 meter by 5 meter box. The boundary can be adjusted depending on species of interest – for example, the boundaries are often expanded greatly when surveying for swallowtails, due to their size and ease of detection.

As the observer slowly walks through the habitat being sampled, any butterfly that flies through this invisible boundary is tallied. Ideally, this method is performed throughout the flight season and over many years to gain information about population phenologies, fluctuations, etc.

Have them practice over a short distance (~100 meters). Instead of species names, they can record butterflies of similar size and color – for example, small/blue, small/orange, large/orange. Have several groups do it and compare results. What would be the implications for each of their results?

Sampling for larvae:

Why sample for larvae?

2 methods:

Sweeping method – for larvae that feed on herbaceous, low-growing vegetation. Students swing the butterfly net back and forth through the upper layer of grasses and herbaceous flowering plants, somewhat slowly so as not to damage the plants. After many sweeps, the students can invert their nets to see the myriad of bugs they have captured, including caterpillars. Discussion question: How would you determine what to raise the caterpillar on, if you desired to do so, after using this method?

Beating Sheet – for larvae that feed on shrubs and trees. An X is form by short PVC pipes or wooden sticks, with a sheet stretch between the corners (the butterfly net can be used if such an instrument is unavailable). The sheet is placed beneath the vegetation to be sampled (generally held just beneath it by the student), and the vegetation is hit hard and repeatedly with the end of the butterfly net. Caterpillars and other insects inhabiting the shrub or tree will fall onto the sheet.

Extensions (should topic or interest arise):

Collecting ethics – demonstration on collecting a specimen – why are specimens important?

Native and non-native – vs. – suitable and unsuitable: the view of resources from a butterfly's perspective.

Butterflies and culture – the impact they've had on metaphors, myths, and art.

Upon conclusion: Discussion of species list created.

What are some limitations? What other data may have been collected?

Examples

- Abundance
- Locations observed (habitat associations)
- Behaviors performed by observed species
- Gender ratios
- Juvenile-adult ratios (more relevant for birds)
- Time of day observed
- Many others

Look at other species that can be found in the area but were not seen that day – can someone visit an area once, and claim to know it?

Why are butterflies important to study?

It is advised that students perform a tick check. Have them shake and check their clothes for any ticks that may have attached themselves during the trip.

Assessment

As each student is given a butterfly, they should all have caught at least one butterfly to be engaged in the activity; some students, however, will not like the act of catching butterflies, and they should not be forced to continue doing so.

Many questions can be asked that relate back to their biology curriculum – questions about sexual dimorphism, convergent evolution, adaptation, specialization/speciation, and many others, are readily available with butterflies. With some of these questions, it is more important to elicit numerous ideas than just one correct answer that ends the discussion.

Lesson Plan: "Butterflies of Washington" - Summer

Objectives:

- Students satisfy their biology field trip requirement.
- Students are introduced to butterfly biology and ecology.
- Students identify, and learn about, many local species to their state and their life histories.
- Students observe and practice butterfly research methods.

Location: Snoqualmie Pass area – specifically, Gold Creek Pond and the ski slopes, in that order. Gold Creek Pond offers great mountain views surrounding a lake along a paved ½ mile trail. This is a popular summer picnic spot – hence why this site is visited first to secure parking. The lessons around this site generally end by the time the crowds start to arrive. The ski slopes are accessed via a short wooded walk along the Pacific Crest Trail on the north side of a graveled parking lot on the west side of the I-5 freeway. Students will also enjoy the variety of berries growing on the ski slopes in August.

Time of Year: Late July through August, with early August being more favorable for butterfly abundance and diversity.

Time Frame: Depart UW at 9:00 AM. Approximate drive time to the trailhead is 1 hour. Typical return time around 6:00 PM.

Equipment: Butterfly net for each student, adequate supply of water, first aid kit, larvae beating sheet, fine-tip sharpie pens for marking demonstration, bags of candy bars for MRR example, viewing jars, envelopes for specimens, forceps for handling butterflies, insect repellent.

Guide: Butterflies of Cascadia by Robert Michael Pyle. This is the most detailed and complete guide for the Pacific Northwest. Other field guides can be used for other regions.

Main activity: Creation of a species list – a list of species encountered.

- Provide a list of species previously seen in the area for easier recording – students can circle species observed.

First lesson: Train students on how to properly catch and handle butterflies.

Butterflies, lessons they exemplify, and related discussion questions:

Swallowtails and hairstreaks: convergent evolution and natural selection of defensive mechanisms (false heads, size [swallowtails])

Whites: Mullerian mimicry - include discussion of Batesian mimicry as well, and the differences between the two. If white butterflies are not aposematically colored (as Lyytinen *et. al.* 1999 suggests), what might be the advantage of being so brightly colored?

Blues: Sexual dimorphism - why has natural selection favored different forms between the genders? Why are some species not sexually dimorphic?

Puddling butterflies: Males gathering at damp earth for nutrient acquisition – a mating behavior where males gather salts and minerals not found in flower nectar to grow their spermatophores.

Phenologies and Resource Dependence: Climate Change Implications
Many butterflies are linked to larval host, nectar sources, and habitats. How might the advancement of climate change affect populations and habitats?
Advance of treeline and its impact on mountain meadows.
Decreasing snowpack and available water to larval host plants and nectar sources.

Additional life history/adaptations as other butterflies are encountered.

How do butterflies of the alpine survive freezing weather?

Activities: These meet the objective that students observe and become familiar with butterfly research methods.

Mark-release-recapture (MRR) studies:

Can be performed at either site.

Mark a couple of butterflies using a fine-tipped black sharpie. Use a larger butterfly for ease of demonstration and observation.

Discuss what insights can be gained by MRR studies.

- Population (abundance) estimates
- Longevity
- Movements

Demonstration (candy bar example): This is useful to demonstrate how a MRR study is performed, as an MRR study on live butterflies in a population is far too time consuming and labor intensive for a day trip, as well as discuss violations in the assumptions.

Equipment needed: 1 large bag, 1 black sharpie, and a population of miniature candy bars (about 6 per student).

1. Place candy bars in bag. Have each student "capture" 2 "butterflies" from the population. Have them mark each with a large black X, so that it will be easy to tell if that individual has been captured before.
   - Assumption: All individuals have an equal probability of capture.
     - Violation: Male butterflies are encountered more frequently, as females tend to hide from these amorous males.

2. Have students release their marked "butterflies" back into the population. Shake the bag to mix up the marked and unmarked "butterflies".
   - Assumption: All marked individuals will mix evenly back into the population.
     - Violation: Studies with Red-cockaded Woodpeckers showed that males marked with red bands were pushed to the edges of the population (shunned) because red is a coloration used in aggression in this species; individuals they encountered always thought the red banded males were being aggressive.

3. Each student will then "capture" 2 "butterflies" from the population. Take a tally of how many of those caught are marked (recaptured). Apply data to the Lincoln-Peterson Index, one of many indices used for population estimates. Get estimate for population.

   $N = Kn / k$ where N = the total population (what we want to estimate)
   K = # of individuals marked on the 1st visit
   n = # of individuals captured on the 2nd visit
   k = # of recaptured (marked) individuals on the 2nd visit

   - Assumption: Captured individuals have the same probability of capture as unmarked individuals.
     - Violation: Small mammals, such as mice, can learn to recognize that traps offer food, bedding and safety for a night, resulting in animals that have been captured before to be more likely to be recaptured.

4. How would intensifying our efforts affect the accuracy of our estimate? Typically, the higher proportion of the population that is marked, the more likely your population estimate will be close to the actual population abundance. Have students draw candy bars until they find two that are unmarked (double sampling effort). Mark them the same as in step 1. Repeat step 2.

5. Repeat step 3. How does the number compare to the first estimate?
   Assumption: Capturing/marking individuals does not cause them stress, and influence them to leave.
   Violation: Much more likely in open populations
   Assumption: Marking the individual does not cause an increase in mortality, whether that is due to stress or injury suffered during marking, or if marking increases visibility of the individual to predators.
   Violation: Toe-clipping in frogs used to be the way amphibians were marked (each frog would have a unique combination of toes clipped). It was later demonstrated that individuals suffered reduced longevity.

6. To demonstrate violations in the last two assumptions, select 2 marked individuals from the bag. Suppose they got stressed after being captured, that they were influenced to leave the population (toss candy bars behind you).
   Select two more marked individuals from the bag. Suppose marking made them more conspicuous to predators (eating these individuals usually draws some laughs).
   How would these violations affect our estimate of the population?
   -Our supposed K in our Lincoln-Peterson index would actually be less, and we would have less of a chance of recapturing individuals (as they no longer reside in the population).

7. Conclude by allowing the students to eat the rest of the population.

Pollard walk:

This is best performed on the trail on the ski slopes.

History of development of Pollard walk and why it's such a prevalent monitoring method.

- Easily trained
- Inexpensive
- Relatively low labor effort
- Easily repeated

The observer imagines they are at the back of a 5 meter by 5 meter box. The boundary can be adjusted depending on species of interest – for example, the boundaries are often expanded greatly when surveying for swallowtails, due to their size and ease of detection.

As the observer slowly walks through the habitat being sampled, any butterfly that flies through this invisible boundary is tallied. Ideally, this method is performed throughout the flight season and over many years to gain information about population phenologies, fluctuations, etc.

Have them practice over a short distance (~100 meters). Instead of species names, they can record butterflies of similar size and color – for example, small/blue, small/orange, large/orange. Have several groups do it and compare results. What would be the implications for each of their results?

Sampling for larvae:

Can be performed at either site.

Why sample for larvae?

2 methods:

Sweeping method – for larvae that feed on herbaceous, low-growing vegetation. Students swing the butterfly net back and forth through the upper layer of grasses and herbaceous flowering plants, somewhat slowly so as not to damage the plants. After many sweeps, the students can invert their nets to see the myriad of bugs they have captured, including caterpillars. Discussion question: How would you determine what to raise the caterpillar on, if you desired to do so, after using this method?

Beating Sheet – for larvae that feed on shrubs and trees. An X is form by short PVC pipes or wooden sticks, with a sheet stretch between the corners (the butterfly net can be used if such an instrument is unavailable). The sheet is placed beneath the vegetation to be sampled (generally held just beneath it by the student), and the vegetation is hit hard and repeatedly with the end of the butterfly net. Caterpillars and other insects inhabiting the shrub or tree will fall onto the sheet.

Extensions (should topic or interest arise):

Collecting ethics – demonstration on collecting a specimen – why are specimens important?

Native and non-native – vs. – suitable and unsuitable: the view of resources from a butterfly's perspective.

Butterflies and culture – the impact they've had on metaphors, myths, and art.

Upon conclusion: Discussion of species list created.

What are some limitations? What other data may have been collected?

<u>Examples</u>

- Abundance
- Locations observed (habitat associations)
- Behaviors performed by observed species
- Gender ratios
- Juvenile-adult ratios (more relevant for birds)
- Time of day observed
- Many others

Look at other species that can be found in the area but were not seen that day – can someone visit an area once, and claim to know it?

Why are butterflies important to study?

Assessment

As each student is given a butterfly, they should all have caught at least one butterfly to be engaged in the activity; some students, however, will not like the act of catching butterflies, and they should not be forced to continue doing so.

Many questions can be asked that relate back to their biology curriculum – questions about sexual dimorphism, convergent evolution, adaptation, specialization/speciation, and many others, are readily available with butterflies. With some of these questions, it is more important to elicit numerous ideas than just one correct answer that ends the discussion.